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THE PLANT DISEASE REPORTER

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FRUIT VIRUS DISEASES IN NEW YORK IN RETROSPECT

Supplement 222 October 15, 1953

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PLANT DISEASE REPORTER SUPPLEMENT

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THE PLANT DISEASE SURVEY
DIVISION OF MYCOLOGY AND DISEASE SURVEY

Plant Industry Station Beltsville, Maryland

FRUIT VIRUS DISEASES IN NEW YORK IN RETROSPECT

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Plant Disease Reporter
Supplement 222 October 15, 1953

HISTORY

The so-called yellow-leaf-drop or physiological-yellow-leaf condition on Montmorency cherry was first reported by Stewart (77) as being of concern in New York State. Subsequently Gloyer and Glasgow (19) reported on the premature defoliation of cherry trees in relation to winter injury. When the present study was undertaken very little was known about stone fruit viruses and virtually nothing was recorded on cherry. In 1942 a handbook (44) was published which brought together information concerning virus diseases affecting stone fruits including cherries. Nine years later a revised handbook was published (1).

A preliminary survey involving visits to every fruit growing district was made of the New York fruit disease situation in 1932. Notes were taken on abnormalities of the various fruits. The most impressive condition observed was a so-called "winter injury" prevalent on the stone fruits, and a systematic mapping or case history study was planned for it. The unfruitful dwarf-leaf condition on Italian prunes was mapped in a few Niagara County orchards. Later, graft transmission demonstrated its virus nature (78). The writer assisted F. M. Blodgett in remapping his apple mosaic orchards. A peach condition simulating little-peach was mapped and followed in Ulster County for several years but was not reported.

Sour and sweet cherry orchards were revisited in the spring of 1933 and several in Ontario and Wayne Counties were mapped for yellow-leaf symptoms. In that year Montmorency cherry trees were found to be shedding numerous yellow and yellow-green leaves about July 1. More than half of the leaves of some trees were on the ground. Over 40 percent of the mapped trees in the "Red Jacket" orchard studied in earlier "winter injury" investigations were designated, after conference with Stewart, as having the so-called physiological yellow-leaf or leaf-drop condition (77). Judging by the inactive buds and stubby terminals on many of the trees, they were suffering from an internal-injury condition.

At the beginning of June 1934 another cherry orchard survey was made, in more counties. The Red Jacket and several other sour cherry orchards were revisited and remapped. At this time true winter injury from the unprecedented cold of the 1933-1934 winter season was evident. One after-effect of the extreme cold was tree death. Another was the development of the silver leaf disease on young Montmorency trees in Orleans County (20). All of these conditions further confused the symptom picture. About June 1, a ring-shaped spot or mottle had developed on some sour cherry trees, some of which had shown yellows symptoms the year before. When revisited late in June mild yellows was again evident on a few of the trees that had shown abundant symptoms in 1933. Thus in 1934 mild yellows symptoms or none appeared on trees with marked yellows the year before, and yellows was present on trees that had shown ringspot symptoms earlier the same season. The appearance and the masking or disappearance of the yellows and ringspot symptoms between seasons was indeed confusing, but a tentative hypothesis was adopted of a variable single causal entity or a mixture of two or more entities of a virus nature.

A ringspot, shot-hole, or tatter-leaf condition was first observed in 1932 in several sweet cherry orchards, of which those near Sodus in Wayne County were selected for further study. Subsequently the affected trees displayed a varied pattern with regard to winter-injury, tatter-leaf, and fruit set. On Yellow Spanish the leaf symptom expression was severe in 1933 and relatively masked in 1934. The extremely cold winter of 1933-1934 killed some of the sweet cherry trees and severely injured many others. Thus surviving trees that had been mapped for typical leaf symptoms with some winter injury in the 1933 season were definitely suffering from more severe winter injury in 1934. Obviously, therefore, the tree injury could be only in part of suspected virus origin. Heavy pruning after the severe cold of 1933-1934 stimulated new growth on affected trees, but the devitalization later found to be due to virus was of course not corrected and resulted in declining productivity.

In 1935 donation by Dansville nurserymen of a considerable quantity of surplus stone-fruit nursery trees for experimental purposes added much to the test planting started at Ithaca in 1934. Propagating materials from two cherry orchards were indexed into some of the dormant test trees by grafting shortly after planting but before growth started. A few buds from diseased orchard trees were also grafted into test trees after growth had started. When observations were made in the spring of 1936, yellows symptoms developed on over 30 percent of the graft-inoculated trees, but approximately 8 percent of the ungrafted check trees also showed yellows symptoms. The occurrence of trees showing symptoms in the checks suggested the need for reorientation of the studies to include observations in the nursery sources of the trees. Properly timed visits to cherry nurseries at Dansville, Geneva, and Honeyoye Falls in 1937 and succeeding years revealed that yellows symptoms were present in nurseries on two-year-old trees. The yellow leaf-drop in the nurseries resembled the condition in orchards and was considered the same disease, but with reservations because symptoms sometimes showed up later in nurseries. This was especially true for the one-year-old nursery trees on which symptoms were manifested only rarely and several weeks after their usual appearance in orchards.

As the greenhouse studies on plum viruses were tapered off in 1937, work was started on cherry viruses. None of the Red June or Burbank plums tested were entirely free from a line-pattern symptom condition later described by Cation (8). Subsequent studies were limited to Italian and Lombard plums. By this time there was circumstantial evidence from the studies on prune dwarf that nurserymen were supplying growers with masked-virus-infected stone fruits, such as line-pattern virosis in Red June and Burbank plums, prune dwarf in Damson plums, and the yellows complex in sour cherries.

To add to the confusion, under greenhouse conditions graft-inoculated sour cherry trees almost invariably failed to develop yellows symptoms. However, after transfer to outdoor test plantings, typical symptoms developed on infected trees during the following growing season. The masking effect of warm temperatures had been reported before in the literature on potato viruses. The only cherry yellows symptoms ever encountered were in the coolest greenhouse (below 65° F.) early in the season. The trees abruptly stopped developing yellows symptoms because the temperature could not be maintained below 68° F. For currant mosaic also it was found later that typical symptoms never developed at 70° and above. Cherry ringspot symptoms, however, usually developed on about one-half of the yellows-inoculated trees regardless of temperature and even on trees for which the bud inoculum came from trees marked as healthy on orchard maps, indicating that another virus must be present. This masking further confused the virus story, and made the indexing of orchard trees for presence of virus necessary before employing their budwood in propagation practice. Probably the most significant step stimulated by this situation was the initiation of attempts to discover other test plants that would be more suitable for indexing in the greenhouse.

The complicated causation factor was not obscured by the central fact that the causal entity, while nonlethal, was definitely devitalizing to the orchard trees and markedly reduced their productivity. Judging by the mapping and other records, the diseased trees never recovered. Little of publishable nature was obtained at the end of the first five years of study, but the expression "winter injury" was definitely taking on a more tangible meaning, with the hitherto unknown causal entities about to be demonstrated and announced. The study of cherry viruses was not aided to any great extent by the concurrent studies on other viruses such as prune dwarf (30, 78), line pattern on plum, peach viruses (24, 47), and currant mosaic (21, 22). Masked infection seemed even more prevalent in plum than in cherry viruses and with less devitalizing effects on most host species.

This report will present a résumé of the results from selected studies on the nature and identity of the virus diseases on sour and sweet cherries and other fruits as carried out in New York and in which the writer participated during the decade from 1935 to 1944.

MATERIALS AND METHODS

Numerous experiments were conducted in orchards, experimental plantings, and in the greenhouse. The orchard experiments were performed in the principal sour cherry counties of Wayne, Monroe, Orleans, Niagara, and Ontario in Western New York, chiefly bordering Lake Ontario. For greenhouse and experimental plantings one and two-year-old cherry trees were used, obtained from reputable nurseries and presumably free from disease. Rootstocks were obtained from nurseries or grown from seeds obtained from seed-producing nurseries in Virginia and from the Pacific Coast. For satisfactory germination of rootstock seeds, suitable seed treatments were required[1].

Dormant grafts were frequently used in transmission tests from cherry to cherry. The usual procedure was to graft dormant scions on stock plants that were dormant or beginning to break dormancy as evidenced by the swelling of the buds. After the breaking of dormancy and loosening of the bark the bud graft proved more practical than the "whip" or "bark patch" grafts, although all three were used in numerous tests.

When employing the rapid-transmission technique (25), especially on peach seedlings, vigorously growing young plants between 16 and 24 inches tall were ordinarily used and bud grafts were made midway on the stem. Pruning just above the inserted bud stimulated new growth at the lateral buds, which ordinarily intensified the symptom expression by its directional effect on the movement and multiplication of the virus and the production of more succulent growth.

Other information on materials and methods will be found in the text.

INCIDENCE AND NATURAL SPREAD OF CHERRY VIRUS DISEASES

The incidence of sour cherry virus diseases was recorded by making maps annually of several orchards in five different counties. The orchards ranged in age from one to 18 years. Sweet cherry orchards were mapped in two counties. In two Montmorency orchards where detailed records were kept for over five years and an indexing check was made in the last year, 1943, every tree was positive for disease. In a typical orchard, when the first map was made in 1938 approximately 38 percent of the trees were marked as having cherry yellows symptoms. The symptomless trees were recorded as healthy. In 1943, at the end of five years, the total of 207 trees was classified under five headings (Table 1). By indexing on Montmorency cherry it was conclusively demonstrated that the apparently healthy trees were all masking the ringspot virus and that not a single tree in the total of 207 was virus-free. This proved to be the case in several other old orchards which were indexed. No young orchard soon after planting failed to show at least a small percentage of diseased trees (yellows or ringspot). In studies on numerous young orchards maps made on succeeding years always showed an increase in the number of diseased trees with time. No diseased tree was ever observed to recover.

Table 1. Summary record of virus disease incidence in Orchard A (Orleans) in 1943.

Virus Symptoms - Complex (Yellows - Ringspot)	Symbol	Trees Number	Trees Percentage	Indexing results (1943)
Severe yellows	YYYY	99	47.9	
Moderate yellows	YYY	56	27.1	
Mild yellows	YY	25	12.0	
Trace yellows	Y	15	7.2	
Apparently healthy	O	12	5.8	All RS*
	Totals	207	100.0	

* Ringspot

Cherry Yellows: One characteristic of cherry yellows virosis is its relatively slow spread in orchards (44, 50). However, a more rapid spread may occur (72). Results were variable from orchard to orchard because change in environment may profoundly influence the activities of the vector, the identity of which still remains unknown. The results on spread obtained in New York orchards correspond to those observed in other places. One difficulty in measuring natural spread is the variability in sequence of developments taking place in trees of different ages. In young trees the sequence is simple. An older tree, instead of developing symptoms throughout in one or two years, may take as long as seven years from the beginning of an infection until the entire tree is involved, by which time it has reached the permanently unprofitable stage.

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[1] The cold period for breaking dormancy of Prunus seed varies between species and may be effected by after-ripening treatments. It ordinarily takes about four months in moist peat at 40°F. to break dormancy of P. cerasi seed, about three months for P. mahaleb, and about six weeks for P. persica.

Seasonal developmental effects are also a factor, as Keitt and Moore (51) have demonstrated. When growing conditions are not conducive for prominent symptoms and the fungus leaf spot (Higginsia [Coccomyces] hiemalis) disease gets out of control, as happened in 1943, it is not uncommon for the trees to show no outward symptoms of yellows, especially in early stages of infection. The most reliable method of evaluation of spread in orchards is to make disease maps annually over a period of five to ten years, as has been done. The common incidence of 1 to 5 percent of disease in young orchards the first year from planting and of 40 to 90 percent in old orchards tells the yellows story, which, however, is greatly complicated by ringspot.

Ringspot and Yellows: One striking characteristic of ringspot virus disease is its relatively rapid spread in young Montmorency orchards, especially on Mazzard roots. One clear-cut case will be cited, that of a young orchard of 396 Montmorency trees on Mazzard roots planted in 1939. One tree showed stunting with positive but mild ringspot symptoms in 1940. The smaller size and the somewhat masked ringspot symptoms plus the shorter terminal growth were evidence that the tree had come diseased from the nursery. One other tree had conspicuous yellows symptoms in 1940, also indicative of nursery origin. Also, these trees were propagated from bud wood certified as disease-free by indexing. The yellows tree was eradicated in 1941. In 1942 another tree developed yellows symptoms and in 1943 a third tree, with the number increasing to six in 1944. These diseased trees were distributed at random as no two trees were closer than ten spaces apart.

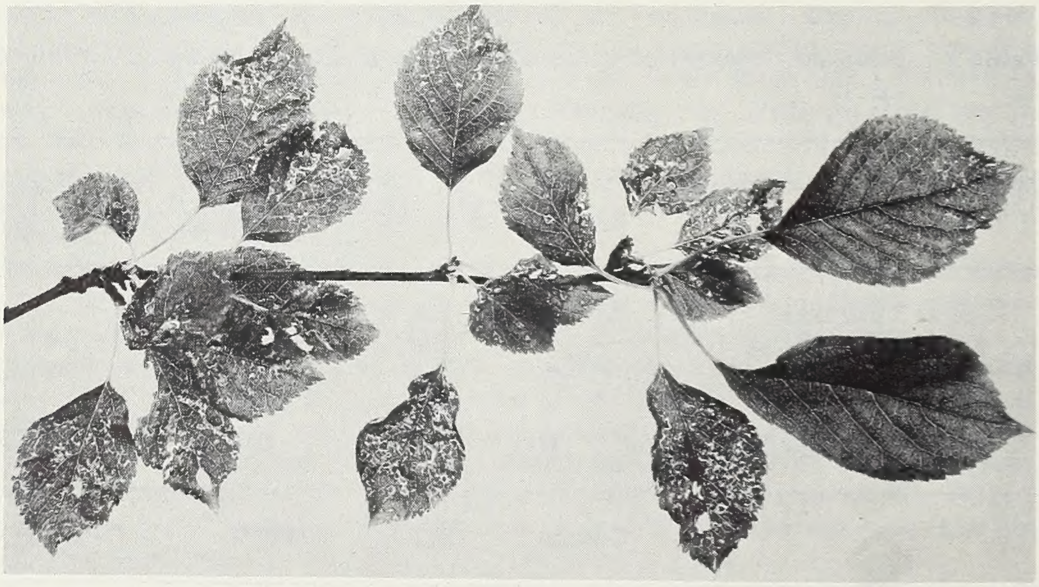


FIGURE 1. Ringspot -- Severe ringspot "shock" symptoms on Montmorency cherry on Mazzard rootstocks. This photograph was taken in mid-summer after partial recovery.

The number of ringspot infections totaled 2 in 1941, 8 in 1942, 36 in 1943, and 105 in 1944. The new ringspot infections were very conspicuous, with the "shock" symptoms consisting of a severe shredding of leaves (Figure 1) and occasional dieback. As in the greenhouse and test planting trials, in the year following the initial shock the necrotic symptoms were much milder, but stunting of growth and reduction of leaf size, called small leaf, were characteristic. The fruits set well but were smaller in size and darker in color than normal. These ringspot infections definitely decreased the vitality and productivity of the trees, from the start. In this orchard the origins of both diseases (yellows and ringspot) were definitely traced to single infected trees that came from the nursery. None of the wild Prunus species growing in the fence row at the south end of the orchard showed any evidence of disease and when indexed none showed evidence of harboring a virus. This case is cited because the complete story was known from the selection of disease-free budwood for nursery propagation in 1937 through 1944 when the observations ceased.

An interesting sidelight was the frequent development of Mazzard suckers under the vigorous young trees in the orchard. In every case without exception when the "shock" symptoms were showing on the Montmorency foliage, severe tatter-leaf symptoms were present also on the P. avium suckers. The writer has suspected for a long time that the vector may prefer the Mazzard to the Mahaleb rootstock, which could account for the more rapid spread when the Mazzard suckers are present, especially early in the season before mowing of the growth between and under the trees just before fruit-picking time.

INCIDENCE OF VIRUS SYMPTOMS IN NURSERIES

Before the general cherry virus disease nursery eradication program was initiated in 1939, yellows-diseased trees were frequently encountered in nursery plantings where budwood had been obtained from orchards. When nursery-grown budwood was used almost invariably a small percentage of individual nursery trees would have yellows or ringspot and it was concluded that diseased rootstocks could be the source in such instances. When incidence was more abundant, the diseased trees ordinarily occurred in series of four to seven according to the number of buds taken from each individual diseased budstick from orchard sources.

Records taken at several nurseries in the same and succeeding years revealed percentages of disease ranging from a fraction of 1 percent to over 90 percent in one nursery containing the Chase variety. In one nursery planting of second-year trees of the Chase variety, consisting of nine rows with 2995 trees, over 95 percent had yellow-leaf-drop symptoms. In 3 1/2 rows of the Early Richmond variety containing 910 trees, for which budwood came from the nursery, only about 3 percent were diseased. In another block of Early Richmond budded from a grower's orchard, with 4 1/2 rows and 1102 trees, over 90 percent showed yellow-leaf-drop symptoms. In two rows of 496 trees of English Morello budded from a grower's orchard about 51 percent showed typical yellow-leaf symptoms. The remainder of this nursery planting of over 30,000 trees, except for two rows of Chase cherry of about 250 trees with over 90 percent showing symptoms, were practically healthy with less than 5 percent of disease in any single row. These relatively disease-free trees had all been propagated from nursery budwood. The nursery cited had customarily propagated from budwood furnished by the larger growers as a special service up to this time. After this visit the Chase variety was completely eradicated along with all affected plants of the other varieties.

Numerous other cases could be cited where disease incidence was much less. In another nursery occasional clumps of diseased trees in groups of three to seven showed a total disease incidence of about 20 percent when the budwood came from growers' orchards. Here again incidence was always small, less than 5 percent, when the budwood came from the nursery; also, diseased trees occurred individually and were widely separated from each other by healthy trees.

The first nursery inspections were made with the full confidence of the nurserymen and in cooperation with the State Department of Agriculture and its horticultural inspectors. In fact, by assisting in the mapping the inspectors were trained in the method of identification employed by the regulatory service before the announcement in early 1940 that yellows was a virus disease. Once the hazards of imported budwood were explained to the nurserymen its use was quickly abandoned. Thereafter all nurserymen took practically all budwood from inspected and certified nursery blocks of trees. In exceptional instances a few budsticks were obtained from marked trees in growing orchards which the college had indexed and certified for freedom from virus before use in propagation. Subsequently serious incidence of virus infections in nurseries was easily traceable to budwood obtained from growers' orchards.

The role of cherry rootstocks in virus transmission and incidence has been reported in detail (43). Studies on the possibility of origin of the virus in rootstocks were conducted from several angles. Receiving attention from the start were: first the presence of chlorotic or virus symptoms on seedling foliage during the first or second year of growth from seed, and second the appearance of single or isolated affected trees in the nursery during the first or second year from grafting. The chlorotic stipple spot and the chlorotic ring or line spot have been regularly observed in Mahaleb rootstock but never on Mazzard. However, tatter leaf (43) has been observed on Mazzard in nurseries to the extent of about 2 percent. The incidence of a low percentage of the chlorotic symptoms on Mahaleb rootstocks and of tatter leaf on Mazzard rootstocks in seedling and variety plantings is obviously a demonstration of seed transmission of these abnormalities. The occurrence of isolated diseased trees in nurseries is also strong evidence implicating the rootstock (seed) as source or origin of the virus. During summer inspection in an outstanding cherry nursery in Michigan where scion sources were carefully checked, the writer observed single individual sour cherry trees with yellows and ringspot symptoms in the nursery rows, ranging from 1 to 5 percent.

The fact that seedling rootstock samples of Mahaleb cherry from certain sources contain more of the chlorosis trouble than others, suggests the possibility that some virus is being picked up from wild plants adjoining the planting. Numerous Prunus species growing wild in nature have been indexed on peach seedlings for the presence of cherry yellows virus, but with negative results. Occasionally, however, the ringspot virus has been obtained from P. virginiana among others.

Judging from surveys of relatively large plantings, the occurrence of isolated diseased plants in seedlings and in nursery varietal plantings accounts for the fact that in young orchards the percentage of diseased trees is usually small at first and gradually increases with time. Observations in nurseries over a period of seven years showed that both scions and rootstocks contribute to the kind and amount of cherry viruses that are released to the trade (25, 26, 27, 29, 32, 33, 34, 35, 36, 37, 38, 43). The scion avenue was relatively easy to control. Virus infection from scions was eliminated by indexing and certifying sources for use by nurserymen. Nursery inspectors were trained to recognize and watch for the more obvious symptoms (28).

LOCATION OF VIRUS IN BUDSTICKS

In studies on transmission of any virus it is important to know its approximate location in the plant, especially in relation to symptom expression. The indexing technique (23), labeled "rapid transmission technique", used so successfully for the peach viruses (X-disease, mosaic, rosette) was also tested in studies on cherry viruses and with some success. It was assumed that in a growing terminal the virus will be present when symptoms are showing. However, yellows symptoms rarely showed on sour cherries under greenhouse conditions owing to prevailing temperatures above 65° F. In addition ringspot symptoms on cherries were always masked after the initial shock symptoms. Hence it was desirable to employ a different medium, such as peach seedlings, as an indexing host in an attempt to get positive results by which to evaluate virus presence (28).

Indexing was employed first to check for the presence of virus in orchard trees during the period of heavy leaf drop. It was noted that at this stage leaf drop included leaves with little or no yellowing visible. This expression suggested that the yellows virus could be present in the absence of symptoms under orchard conditions, and also where symptoms were masked during high temperatures whether in the greenhouse or in the field. Several indexing experiments verified this conclusion with the production of stunting and rosette on peach seedlings from cherry buds below, at, and above the leaf last showing yellows symptoms while still attached to the tree. The results were variable as between experiments and frequently indicated presence of more than one virus. Dieback and bark cankers on peach were found to represent the presence of ringspot virus. Cherry buds taken from the axils of symptomless leaves frequently indexed for ringspot, yellows, or ringspot-yellows. When pruning was not employed the indexed peach seedlings usually remained symptomless for the remainder of the growing season, which demonstrates the importance of the "rapid transmission" technique.

SEED TRANSMISSION OF CHERRY VIRUSES

The seedborne nature of cherry viruses was postulated when only isolated individual cherry trees developed symptoms in nurseries and when affected Mazzard and Mahaleb seedlings were first observed in nursery plantings in 1938 and 1939. However, in the first nursery observations it was recognized that wild Prunus species in the vicinity could be a contributing factor. The first report on the seedborne nature of the so-called tatter-leaf or ringspot virus disease was made by Hildebrand (43). This report was based on studies conducted at a nursery experimental planting at Dansville, New York during 1942 and 1943. Out of the composite sample from many sources, less than 2 percent of the Mazzard seedlings that grew developed tatter-leaf symptoms on the first growth. The high seed mortality, however, presumably was caused by virus devitalization below the point of embryo survival. The presence of large Mazzard

(P. avium) trees showing symptoms in the vicinity of diseased sour and sweet cherry orchards raised the question whether the virus went to or came from this source. Seeds from such trees when germinated always had a very high mortality and a small percentage of tatter-leaf infections appeared in the few trees (seedlings) that grew.

Cochran (15) reported passage of the ringspot virus through Mazzard cherry seeds. In June dormantized stored cherry seeds at about two months after planting were showing some leaves with crowded ring patterns. Of 467 commercial Mazzard seedlings that grew, 25 or 5.39 percent developed symptoms. This is another good demonstration that the ringspot virus can invade and be carried in Mazzard seeds.

Cation (10, 11) demonstrated seed transmission of sour cherry ringspot and yellows-complex viruses. Mahaleb and Montmorency seed collected from trees apparently infected with yellows-complex were germinated in February and grown for four months in the greenhouse. Grafts made from the Mahaleb seedlings to peach seedlings in the field indicated over 20 percent transmission with half of the infected peach trees showing ringspot and the other half showing typical rosette (cherry yellows) symptoms. Similar inoculations with Montmorency seedlings resulted in more than 20 percent disease transmission, but only the ringspot virus was transmitted through the Montmorency cherry seed. It was demonstrated that at least 10 percent of the Mahaleb seeds transmitted the ringspot virus and at least 8.7 percent transmitted the cherry yellows-complex. The cherry yellows-complex was not transmitted through Montmorency seed in the first experiments, but at least 30 percent of the seeds carried the ringspot virus. This is the first detailed account of seed transmission of cherry yellows-virus complex. It emphasizes the need for a disease-free source of seedlings in programs of stone fruit virus certification, and particularly for cherry understocks. It is possible that Cation's indexing technique with peach seedlings revealed some of the milder ringspot strains that would have been totally masked on sour cherry. In conclusion, the vitally important fact is that viruses of cherry are seedborne, which makes the rootstock of importance equal to if not greater than the scion source, particularly because seeds and seedlings cross State boundaries.

SYMPTOMATOLOGY

Yellows and ringspot, the two most important cherry virus diseases, have been observed in every commercial orchard under observation in New York. From the beginning of this study in 1933, these symptoms were frequently observed on Montmorency, Early Richmond, English Morello, and Chase. In the orchard mappings for symptoms, the Montmorency and Early Richmond varieties were more conspicuously affected by this virus complex than English Morello. Presumably this could be due to their more vigorous growth. However, in one exceptional case in 1939 yellow leaf defoliation in a vigorous cultivated orchard was practically as severe on English Morello as on Montmorency with over 50 percent defoliation on many trees. In all other years the leaf loss has been much less on English Morello.

In 1941 the yellows symptoms were showing during the first week of June, or about two weeks in advance of the average season, which had ranged from June 16 to July 6 during the preceding 13 years. By the last week of June 1941, leaf drop had practically ceased on Montmorency and Early Richmond, but symptoms were still developing strongly on English Morello. This had been the customary sequence with English Morello lagging behind the others by about a week.

Both yellows and ringspot symptoms frequently occur on the same tree, as determined by mappings made to show ringspot appearance as the leaves unfold and yellows about one month later. On occasional trees other symptoms were observed such as green-ring yellows, rosette, and mottle. Neither of these orchards were associated with X-disease of peach. Evidence indicates that the yellow-red or X-disease virus has been present in sour cherry orchards since at least as early as 1938 (Stoddard et al., in 1) although its identity was first proved in 1947 (Palmiter and Parker (67) and Parker and Palmiter (68)). X-disease is observed to be most abundant in the part of the orchard adjacent to diseased chokecherries. The symptoms include delayed bloom, extensive June fruit drop especially on English Morello, and failure of remaining fruit to mature with full color and flavor.

Following is a resume of symptoms of the respective viruses of sour and sweet cherries.

Yellows: Yellows is the most conspicuous sour cherry virus disease. Two symptoms are abrupt seasonal yellowing of the leaves accompanied by defoliation usually during the month of June. Yellows on Montmorency cherry is illustrated in Figures 2 and 3 from two severely infected terminals at the beginning and the end of the yellow-leaf-drop season in 1941. Young infected trees rather quickly developed the advanced "weeping" symptoms characterized by the death and loss of fruit buds where leaves had fallen prematurely. Figure 4 illustrates the second-season performance of a bud in the axil of a defoliated yellow leaf marked by string on a first-year tree while the yellow leaf was still attached in midseason. Note the extreme dwarfing and delayed development of the bud. In older trees several years usually pass before the advanced stage of devitalization is reached. Eventually only the previous season's terminal growth sets and bears fruit, but both fruits and leaves may be larger than normal in size. Nursery trees usually delay or fail to produce yellow leaf symptoms on the first season's growth after budding. In the second season, which is usually the last in the nursery, symptoms usually appear coincidently with those in orchards. Nursery inspectors have been advised to make the June inspection with great care since subsequent inspections in July and later will locate only a small number of diseased trees.

The character of the yellow leaf condition on diseased orchard trees in late July or August, which is several weeks after the main wave of leaf drop, is illustrated in Figure 5. It shows the typical shoot condition on yellows trees on August 15, 1941. The continued development of yellow leaf during the summer of 1941 was correlated with and conditioned by temperatures low enough to favor symptoms, which appeared as late as October.

Ringspot: Ringspot is a widespread, nonlethal, and often masked disease which attacks sour and sweet cherries whether on Mahaleb (Prunus mahaleb) or Mazzard (P. avium) roots. Other names for it are "shredded leaf" and "little leaf". Typical early stage symptoms of ringspot are illustrated in Figure 6. Note the dark, concentric rings on the upper leaf surface visible only by reflected light. This photograph was made one month after grafting at about the time the leaves are unfolding in the spring. After the dark rings become necrotic, 9 to 14 days later, the symptoms by both reflected and transmitted light are illustrated in Figure 7. While there is a great deal of recovery of symptom-showing leaves and complete masking on later formed leaves, the necrotic symptoms on Montmorency persist to the end of the growing season with some tendency for some leaves to have a metallic tinge (Figure 8).

Following inoculation into healthy trees, necrotic ringspot and terminal dieback are produced in a short period of time followed by recovery from conspicuous symptoms. Despite masking of the spot and dieback necrotic symptoms the affected cherry trees showed a reduced vitality making them shorter lived, more subject to winter injury, and less productive of fruit, with the leaves and fruits smaller in size than normal.

On peach seedlings some strains of ringspot produce a striking dieback and bark canker when the rapid transmission technique is employed (Hildebrand, 23). Some strains of ringspot may leave the peach symptomless. When certain strains of ringspot virus were inoculated into Montmorency trees much more conspicuous and severe symptoms were produced in trees on Mazzard than on Mahaleb roots. Of great significance is the relatively high percentage of orchard trees carrying ringspot virus partially to completely masked for spot symptoms. Young diseased trees are shy bearers. In general the symptoms develop a few days later in the English Morello and Chase varieties. Figure 9 (the middle leaf) illustrates a cherry leaf with ringspot visible and showing the "yellows" shape, being more elongate and larger than normal. This illustration shows the combined effects of two viruses.

Green-Ring Yellows: Green-ring yellows or mottle (Rasmussen, 70) is relatively uncommon in New York State. Based on observations in 1940 it was relatively more prevalent in Michigan and Wisconsin. Figure 10 shows typical green-ring yellows symptoms with deep green rings (from 1/8 to 1/4 inch in diameter) on a yellow background. These symptoms occur a few days later than yellows. Spots vary considerably in character with some being nearly circular and others in irregular bands. Incidentally fungus leaf spot was much less serious on green-ring yellows trees than on others (Hildebrand, 38). Affected trees have leaves approximately normal in size, larger than for ringspot and smaller than for yellows. This virus seems less devitalizing to the trees with much less leaf fall under New York conditions.

Rosette or Vein-Clearing: Rosette has been encountered relatively infrequently in New York cherry orchards. A single case was reported from Canada (Willison, Berkeley, and Chamberlain, 82). Typical foliage symptoms are shown in Figure 11. The leaves are narrowed, cupped, distorted, brittle, thickened, stiff, less pubescent and sometimes bronzed. It illustrates the advanced rosette stages at the terminals with leaves crowded into a cluster. Vein clearing may be marked in the advanced stages of disease (Figure 12). Rosetted trees are so barren of fruit that orchardists remove them promptly because of their unproductivity.

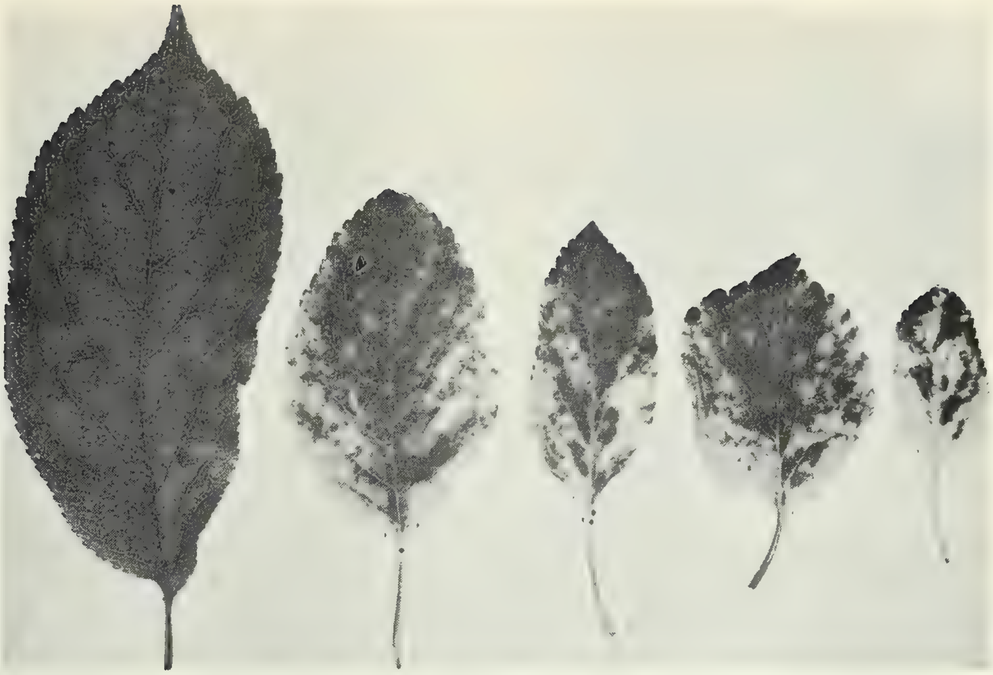


FIGURE 2. Yellows -- Yellow-leaf symptoms beginning to appear on June 3, 1941, two weeks in advance of regular time. The first leaves to turn yellow were at the base of the spur on the small, first-formed leaves, which dropped when the stem was jarred.

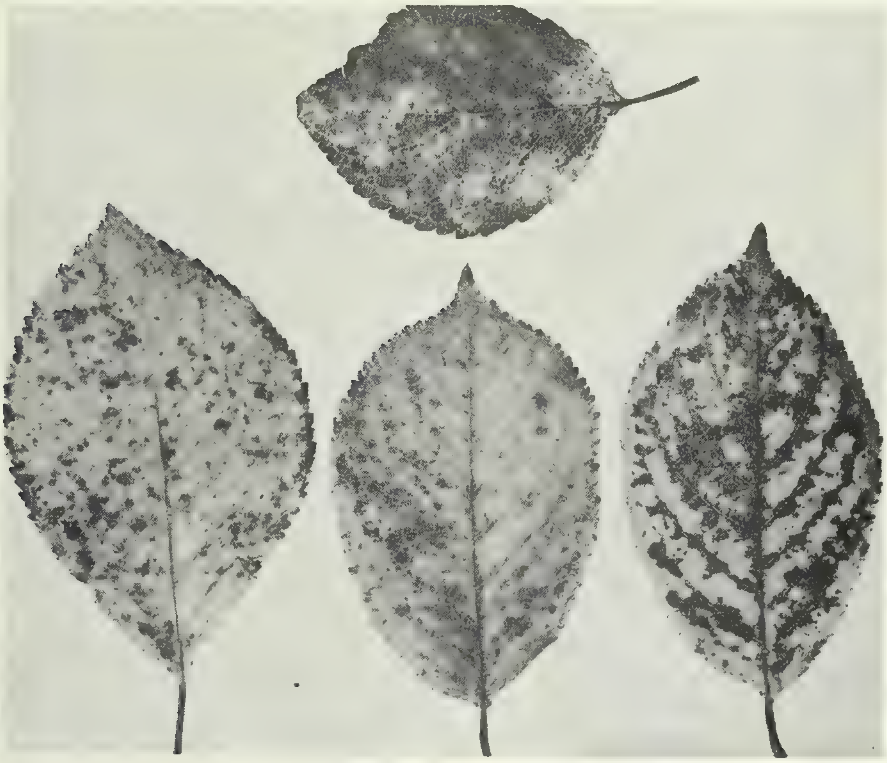
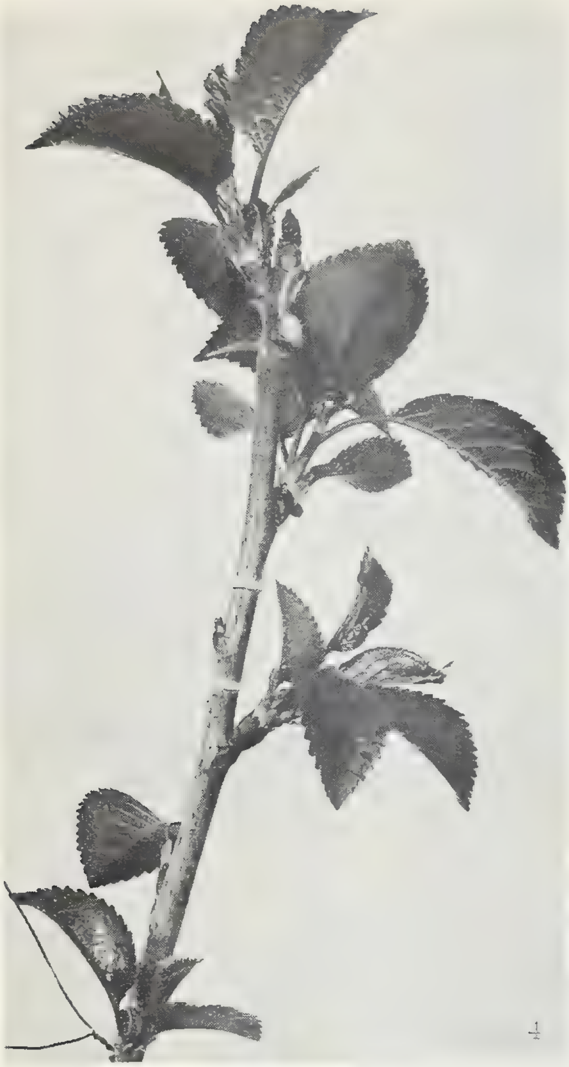
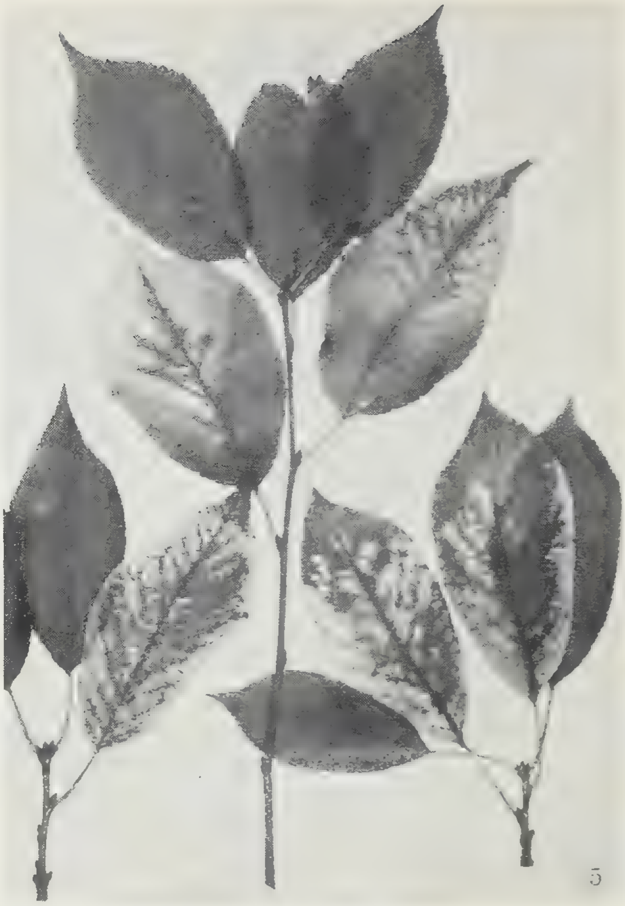


FIGURE 3. Yellows -- Characteristic yellow leaf symptoms on June 30, 1941, at close of leaf-drop season.





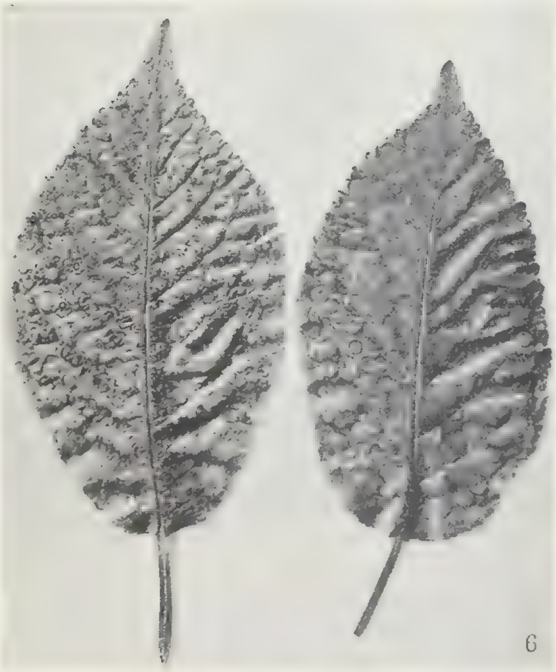


FIGURE 4. Yellows -- Extreme dwarfing and delayed development of a bud (marked by string above and below) which developed at the axil of a yellow leaf on a first-year tree in the nursery in late July 1941 and was inactive as the 1942 season got under way.

FIGURE 5. Yellows -- Typical condition of certain shoots on yellows-infected Montmorency trees on August 15, 1941, two months after the main period of leaf drop.

FIGURE 6. Ringspot -- Dark concentric rings on upper surface of leaf visible by reflected light only. This early stage of ringspot usually appears within one month after graft transmission. (Photographed March 27, 1942)

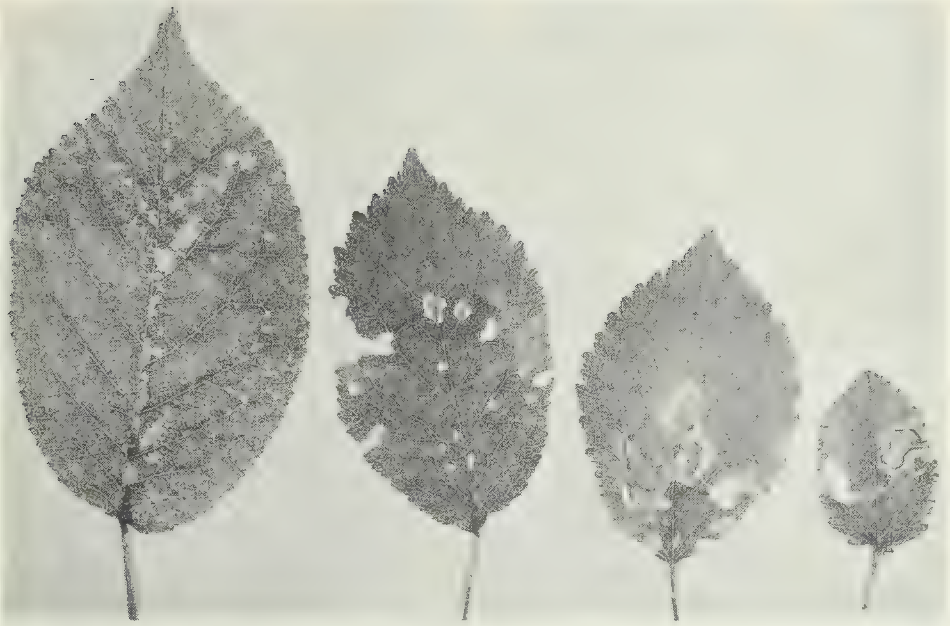


FIGURE 7. Ringspot -- Necrotic ringspot and shot-hole stage which follows one to two weeks after the earlier (Fig. 6) ringspot stage and sometimes within one month from grafting.

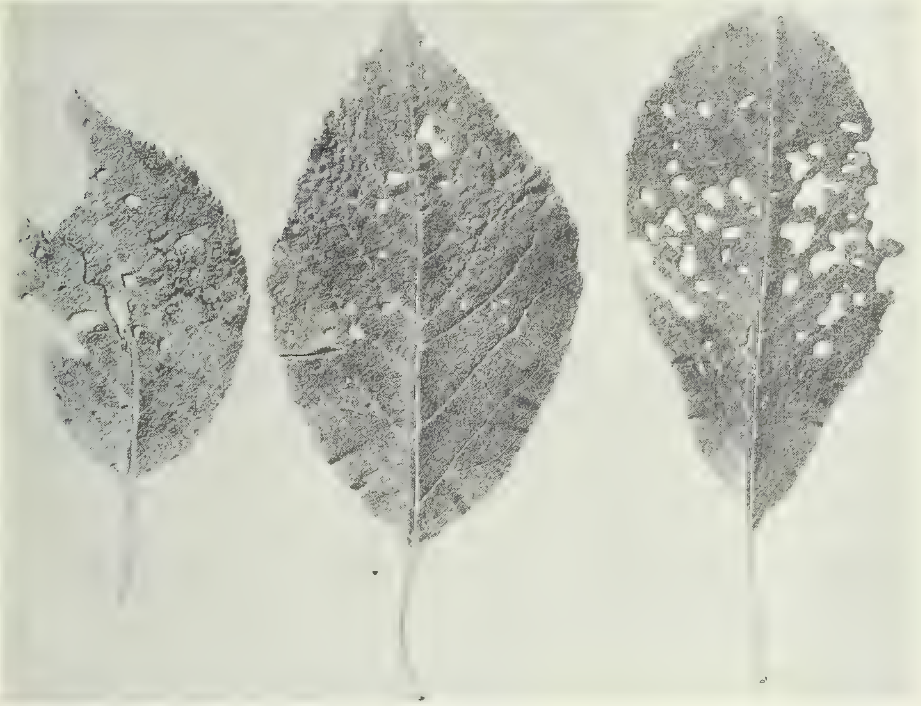


FIGURE 8. Ringspot -- Typical late season symptoms (September 17, 1941) of ringspot disease on Montmorency. Such leaves remain attached to stem and do not drop until end of season.

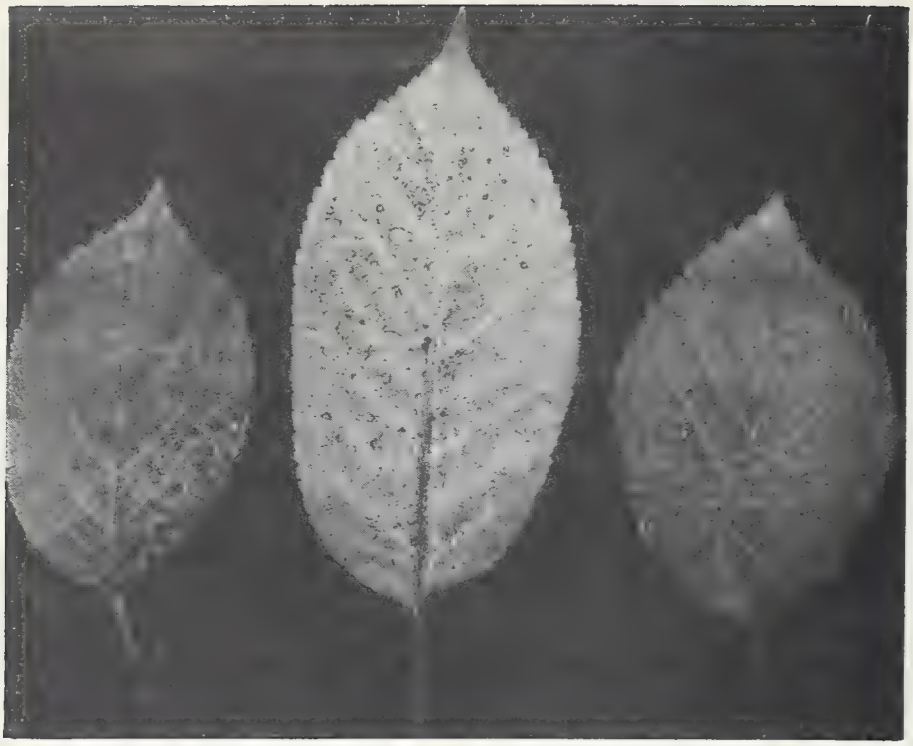


FIGURE 9. Ringspot -- Typical ringspot leaf symptoms resulting from graft inoculation with diseased material (left to right) from Wisconsin, New York, and Michigan, about two months after inoculation. The middle leaf shows the "yellows" shape.

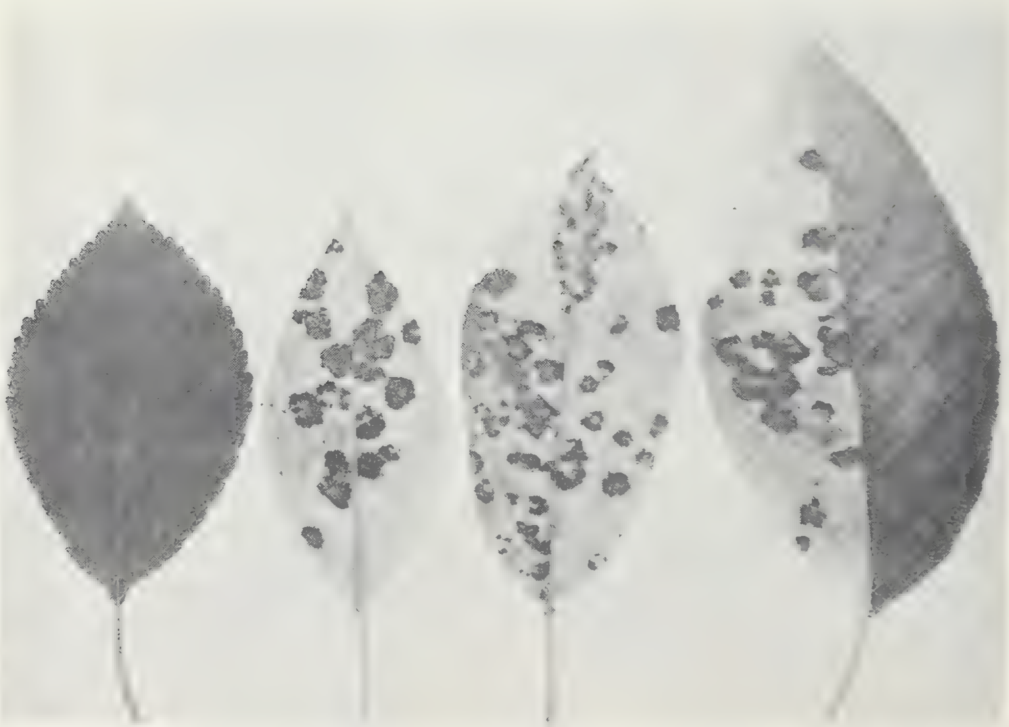


FIGURE 10. Green-ring yellows -- Typical green-ring mottle or yellows symptoms on Montmorency cherry in early July 1942.

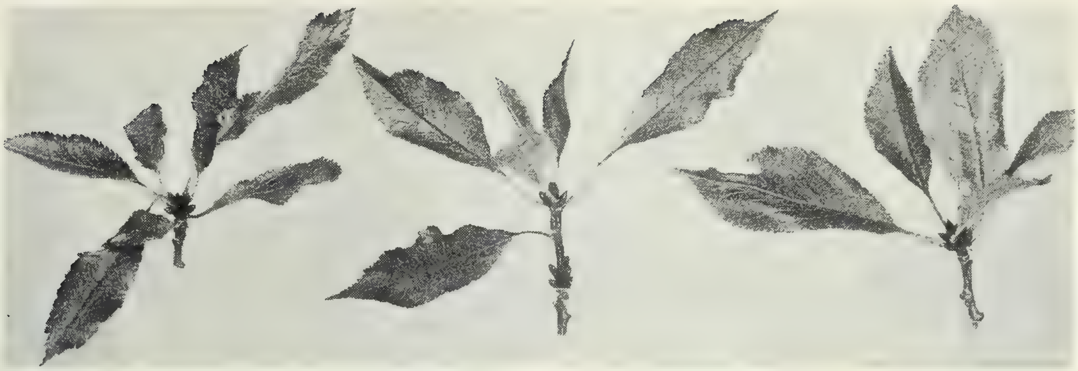


FIGURE 11. Vein-clearing or rosette virosis of Montmorency -- Brittle, dwarfed, crinkly, erect leaves occur as rosettes on the terminals. Photograph September 17, 1941.

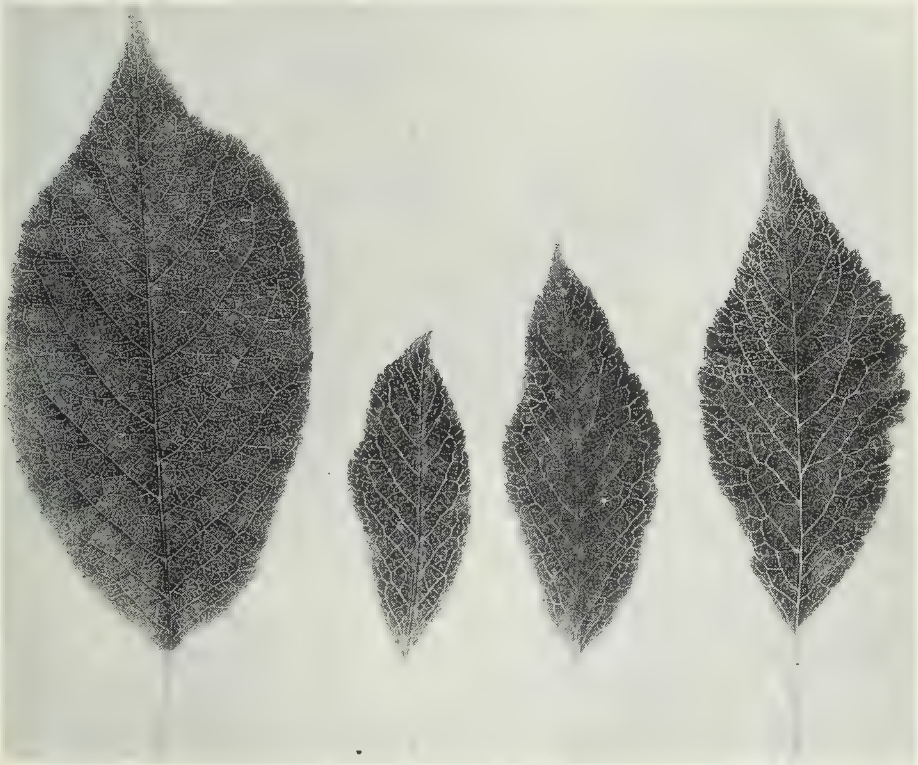


FIGURE 12. Vein-clearing or rosette virosis of Montmorency cherry showing typical vein-clearing, leaf shape and size. Photograph September 17, 1941.

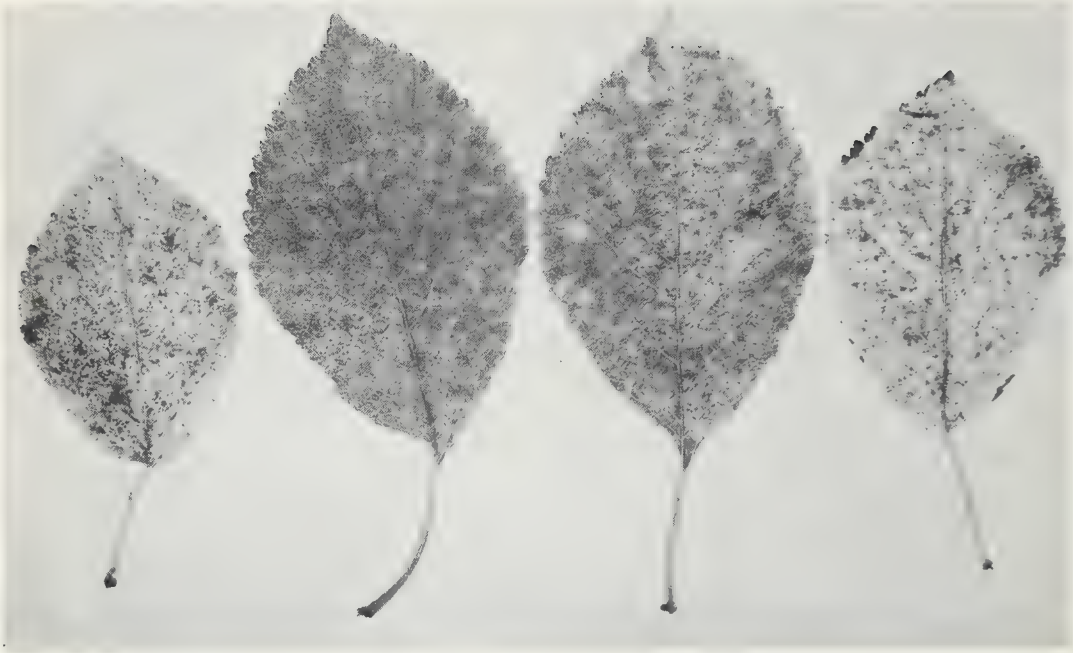


FIGURE 13. Cherry mottle symptoms found on the foliage of Montmorency cherry trees, associated with an abnormal fruit condition, in Niagara County. Photograph July 15, 1942.

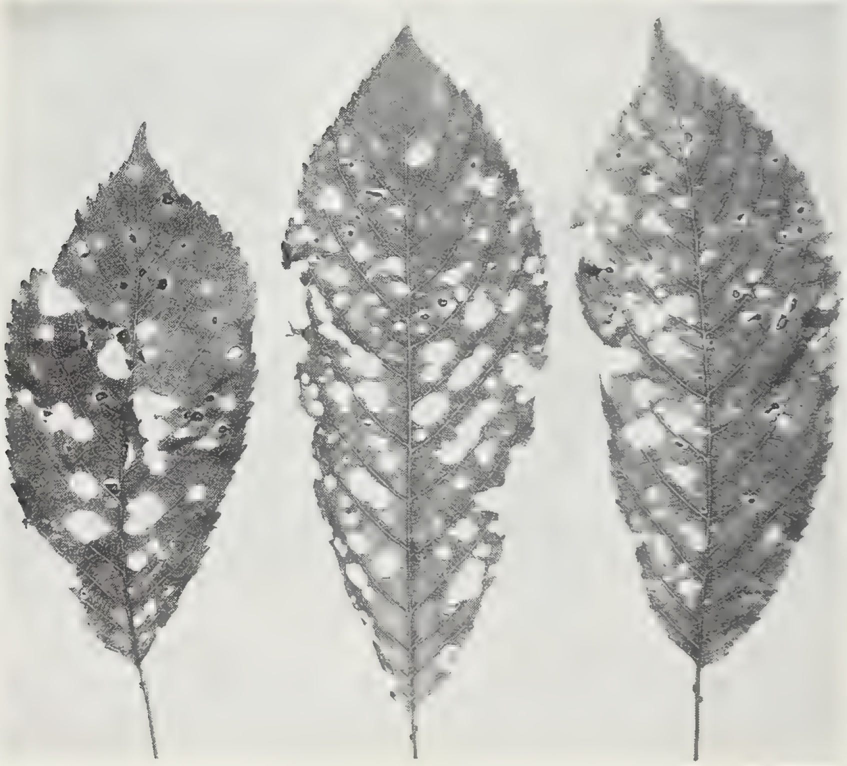


FIGURE 14. Typical ringspot, shothole, or tatter-leaf symptoms on sweet cherry.

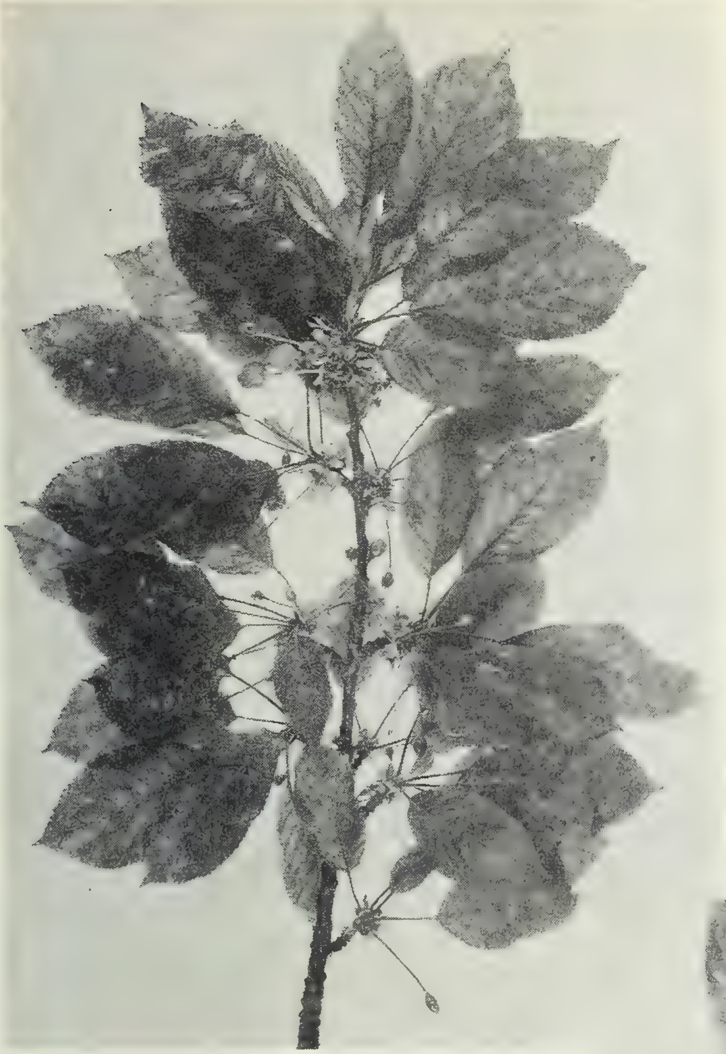


FIGURE 15. Common early season leaf symptoms of virus disease on Yellow Spanish sweet cherry showing adverse effect on fruit set.

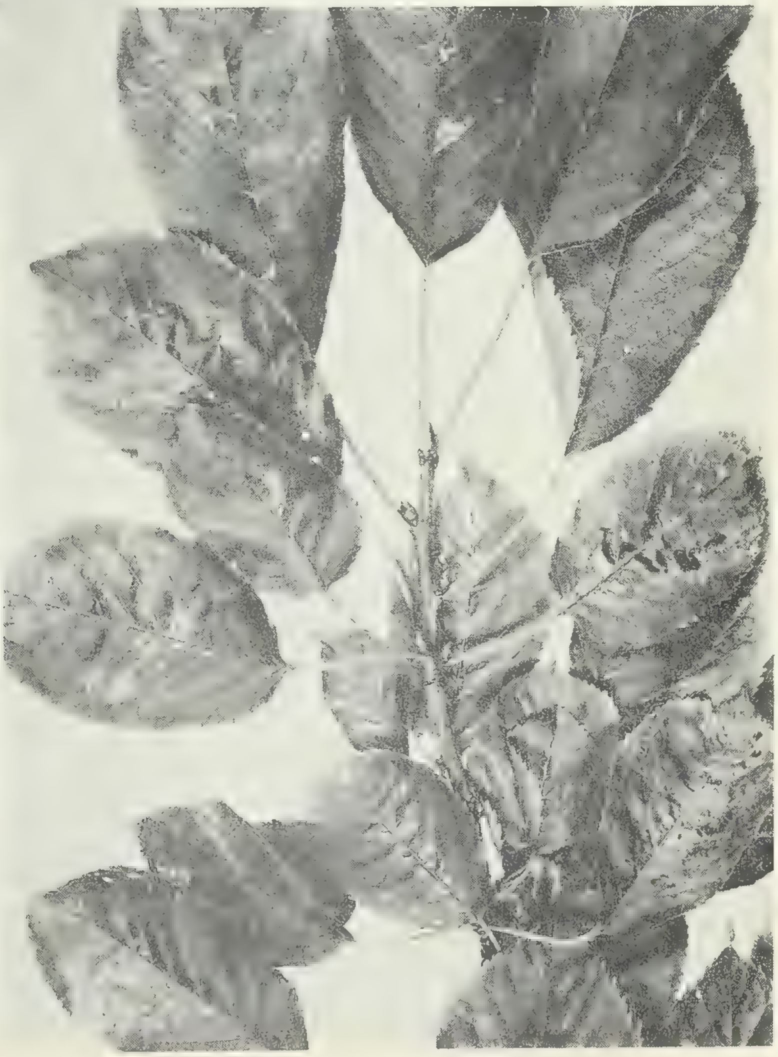


FIGURE 16. Sweet cherry ringspot (chlorotic and necrotic) symptoms on Yellow Spanish, September 17, 1941.

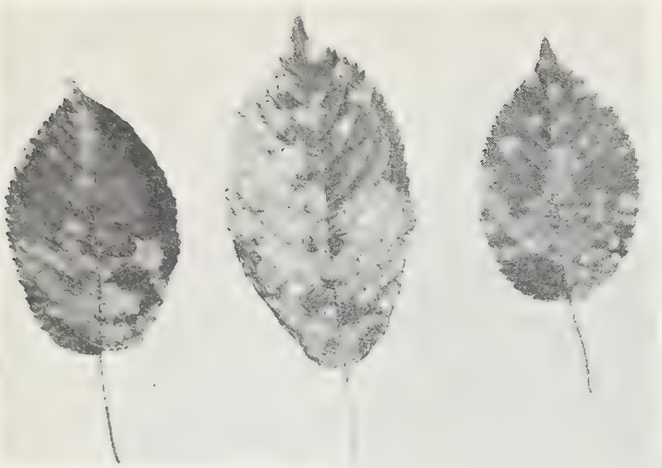


FIGURE 17. Typical chlorotic followed by necrotic ringspot symptoms on naturally infected trees of Prunus avium in Wayne County during July, 1943.

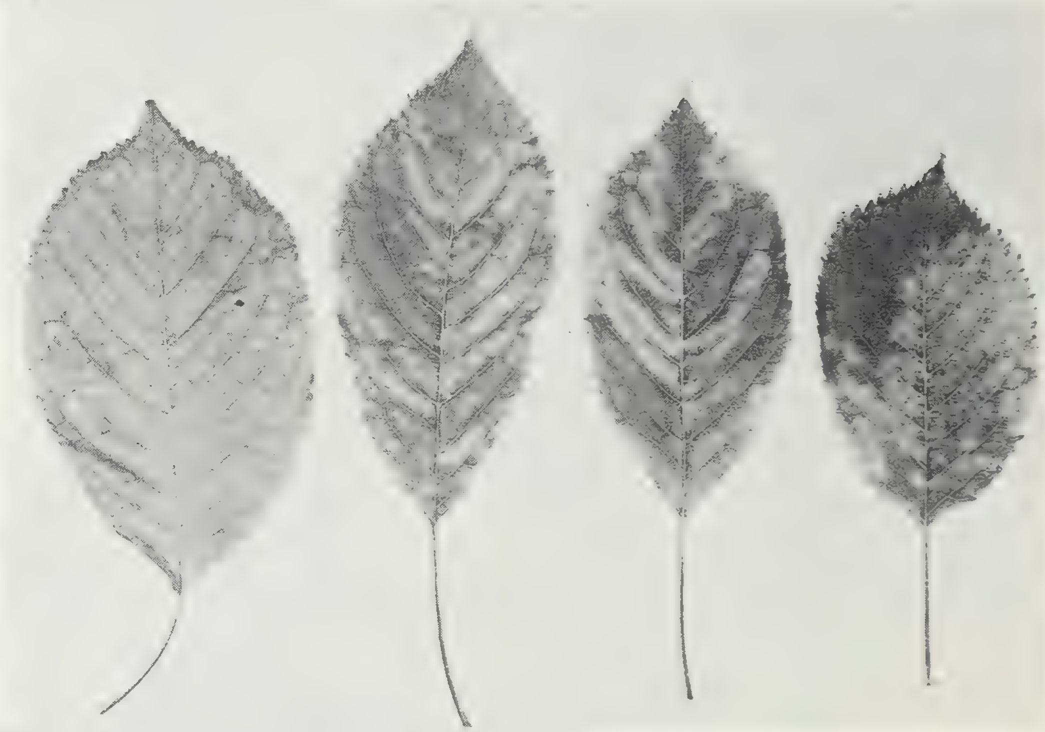


FIGURE 18. Sweet cherry mottle, characterized by chlorotic spotting of foliage, on Yellow Spanish on September 17, 1941.

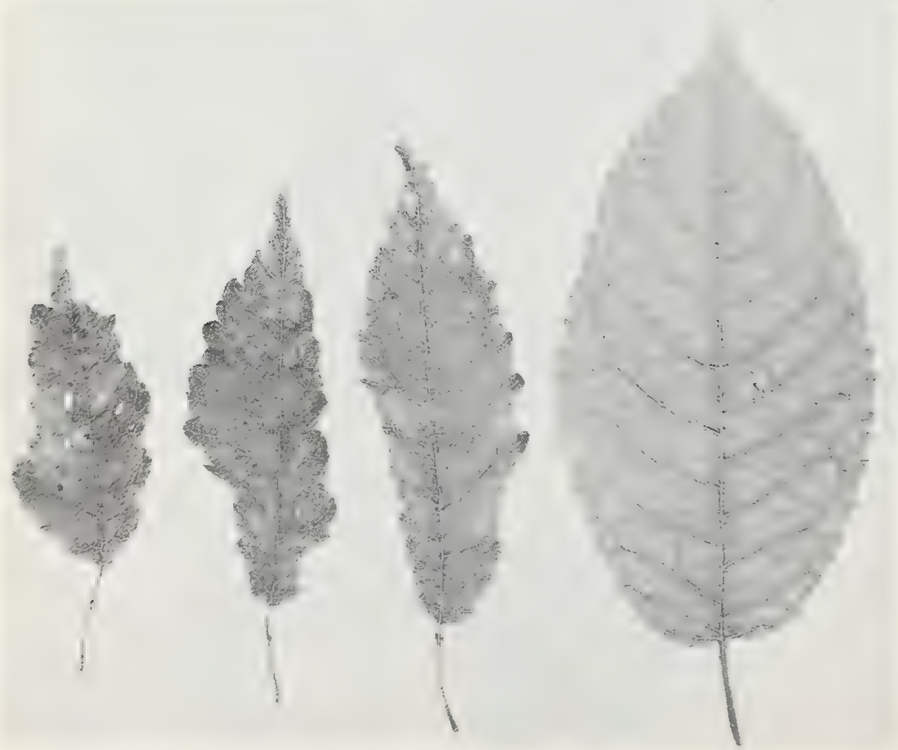


FIGURE 19. Sweet cherry crinkle, a seed-borne, bud-perpetuated condition of Mazzard cherry (healthy leaf at right).

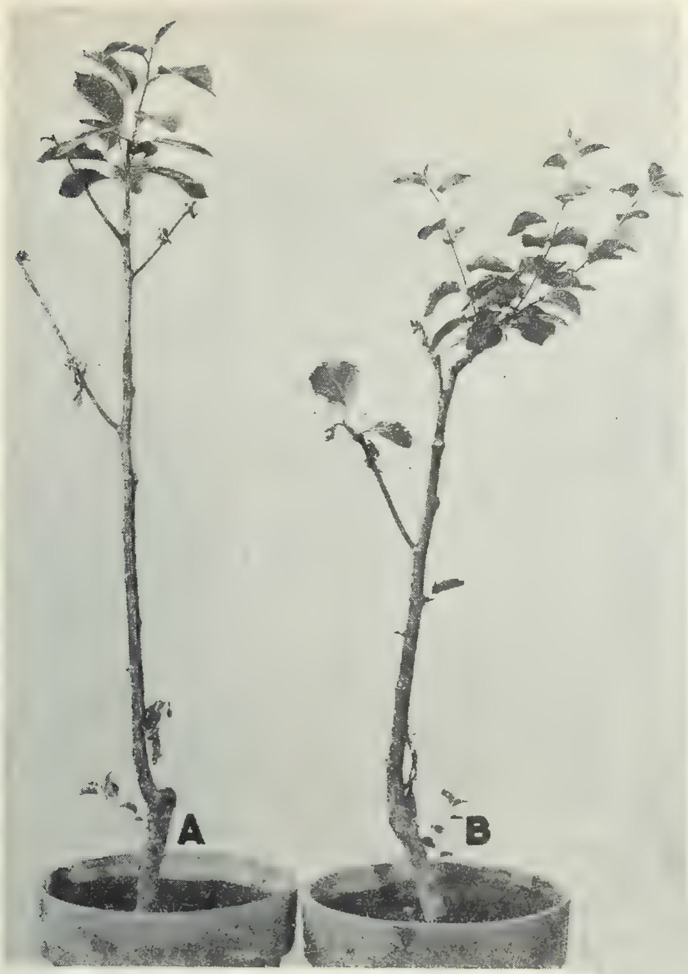
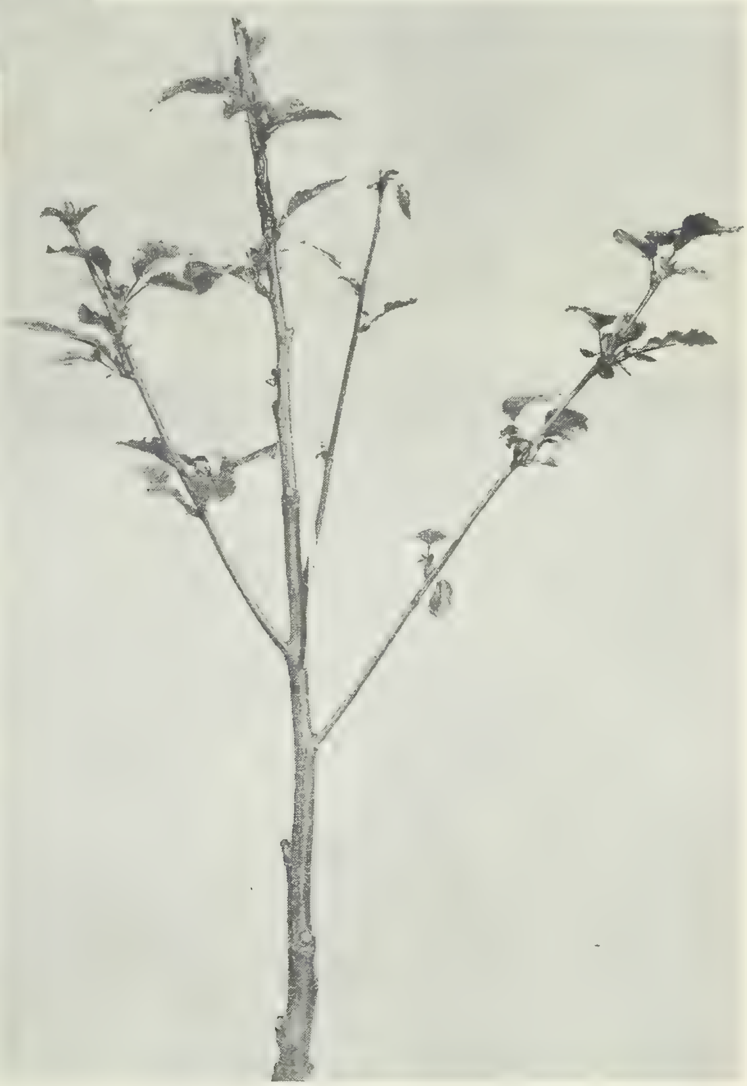


FIGURE 20. Severe necrotic (shock) symptoms induced on first new growth of Montmorency cherry when grafted in dormancy with scion from ringspot-infected Montmorency orchard tree (on left) and scion from Mahaleb rootstock of another infected tree (on right). Note that the scions are symptomless.

FIGURE 21. Terminal killing or blighting accompanying severe necrotic ringspot and shothole on Montmorency in this case affecting all terminals except scion at top center. Note that recovery is progressing within about two months from grafting.



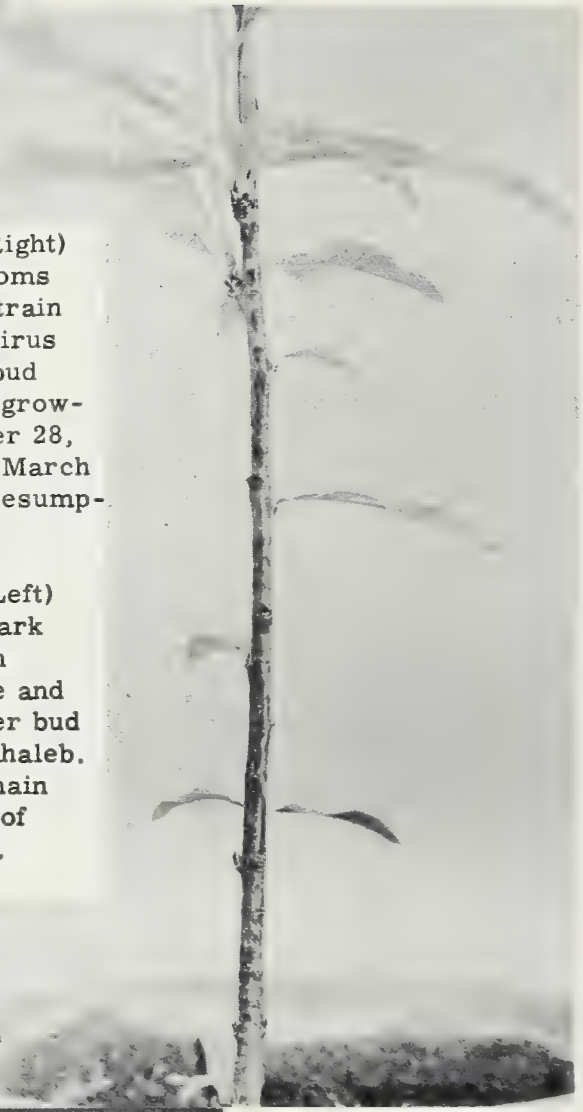


FIGURE 22. (Right) Showing bark symptoms induced by severe strain of cherry ringspot virus on peach seedlings bud inoculated at end of growing season September 28, 1941, photographed March 27, 1942 following resumption of growth.

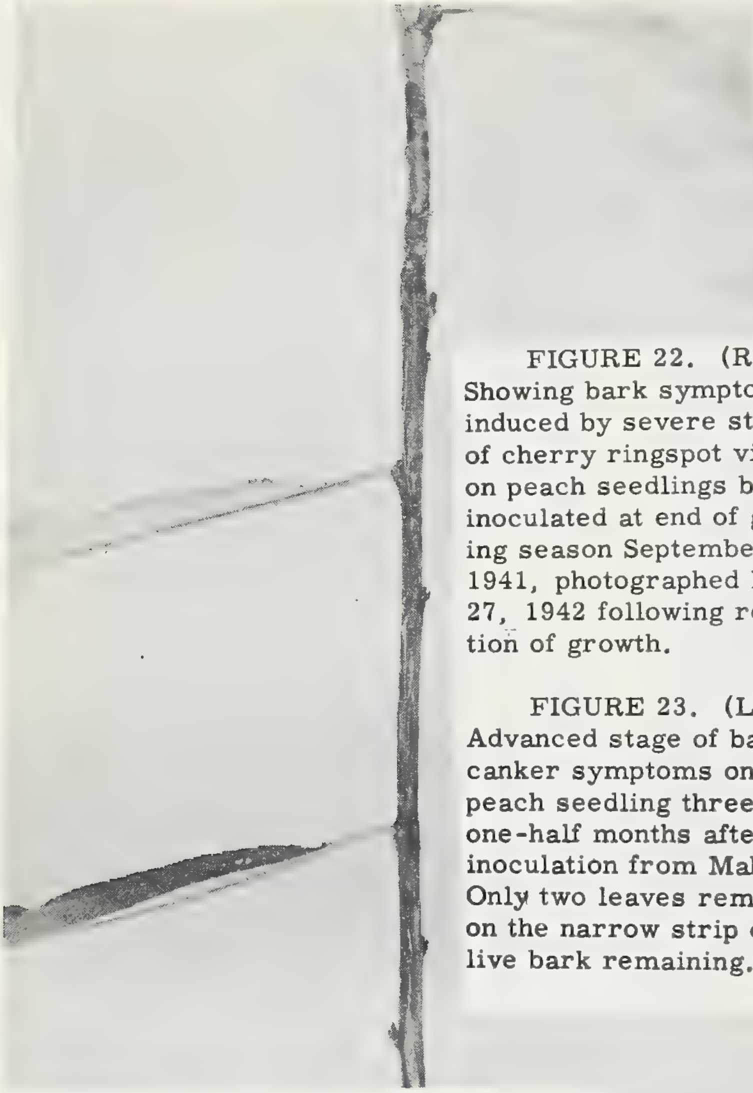


FIGURE 23. (Left) Advanced stage of bark canker symptoms on peach seedling three and one-half months after bud inoculation from Mahaleb. Only two leaves remain on the narrow strip of live bark remaining.

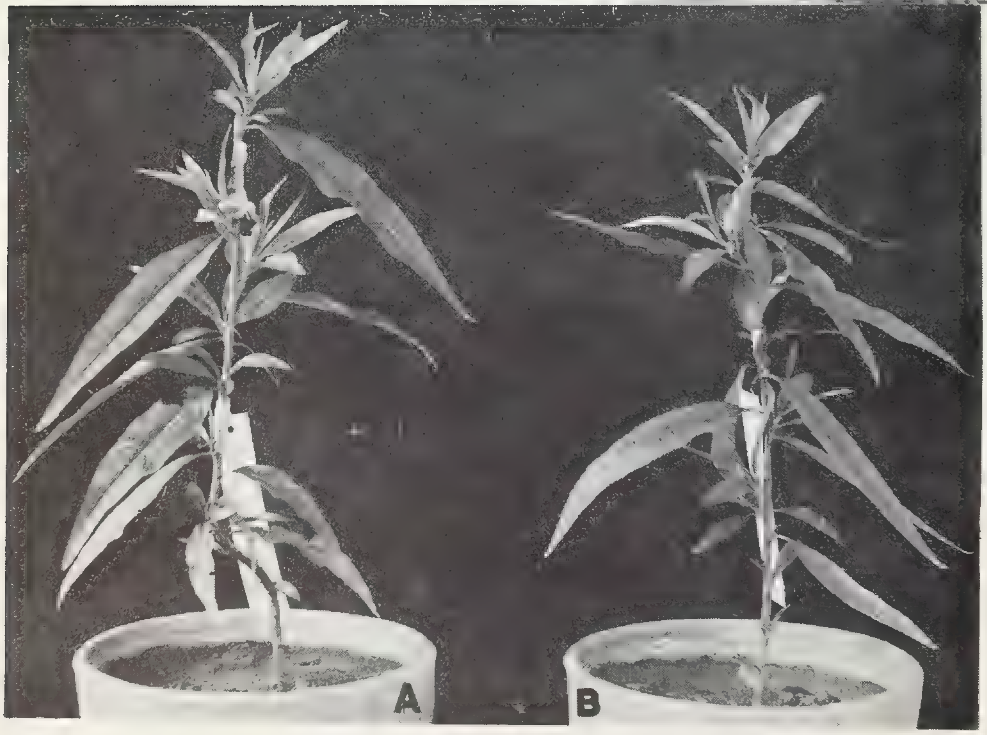


FIGURE 24. Early symptoms on peach seedlings three weeks after bud inoculation, (A) with cherry yellows, and (B) with cherry ringspot.

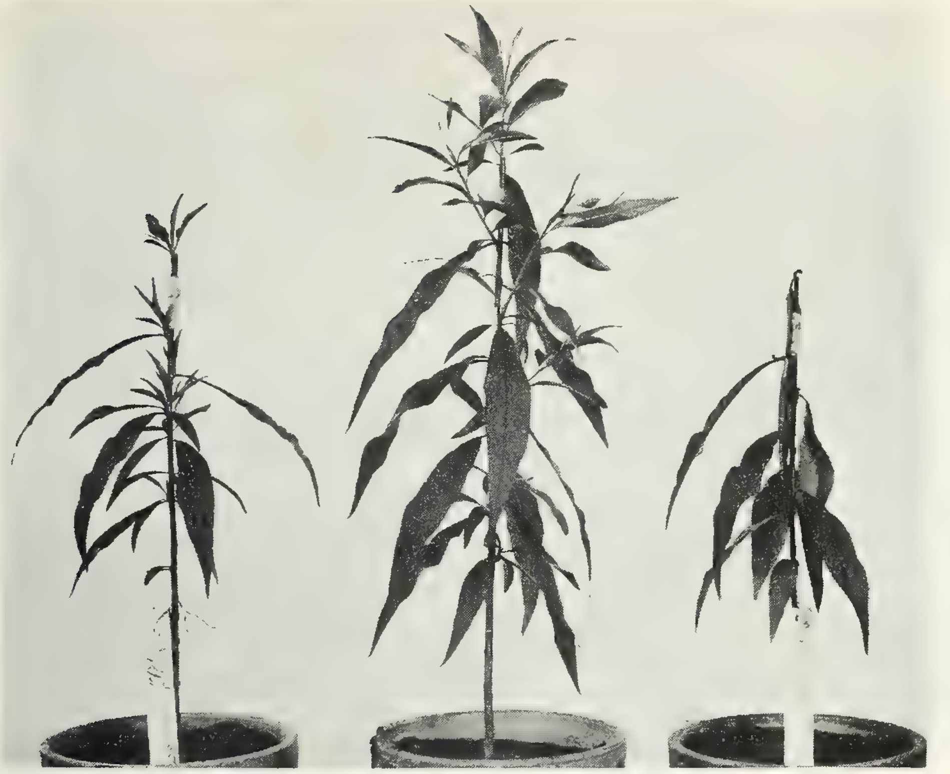


FIGURE 25. On left, rosette symptoms on peach seedling at three weeks resulting from bud inoculation with cherry yellows compared with dieback from bud inoculation with cherry ringspot (on right), with healthy budded check in the middle.

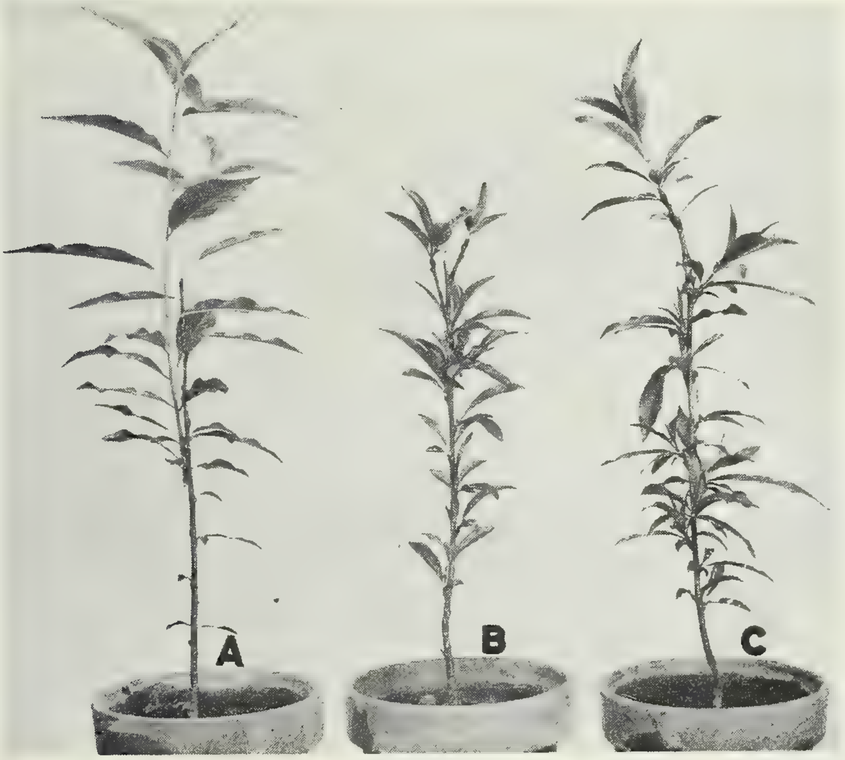


FIGURE 26. Early stage symptoms on peach seedlings (budded in late fall 1941 and photographed March 27, 1942) consisting (a) of dieback and recovery from ringspot, (b) stunted erect rosette growth from vein-clearing rosette virus, and (c) yellows type of rosette growth.

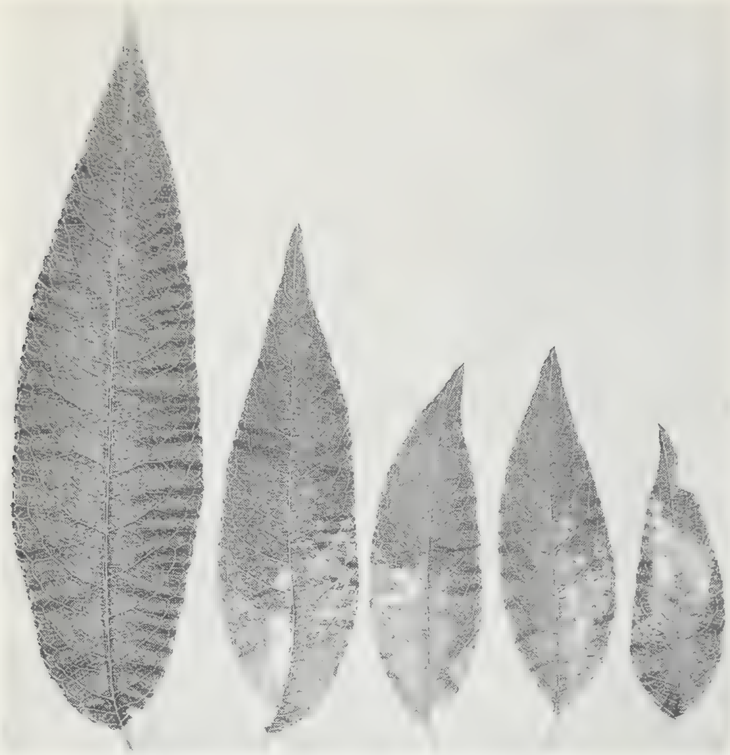


FIGURE 27. Leaf spot symptoms on Elberta peach about one month after bud inoculation from yellows-affected Montmorency cherry (Photographed April 14, 1941).

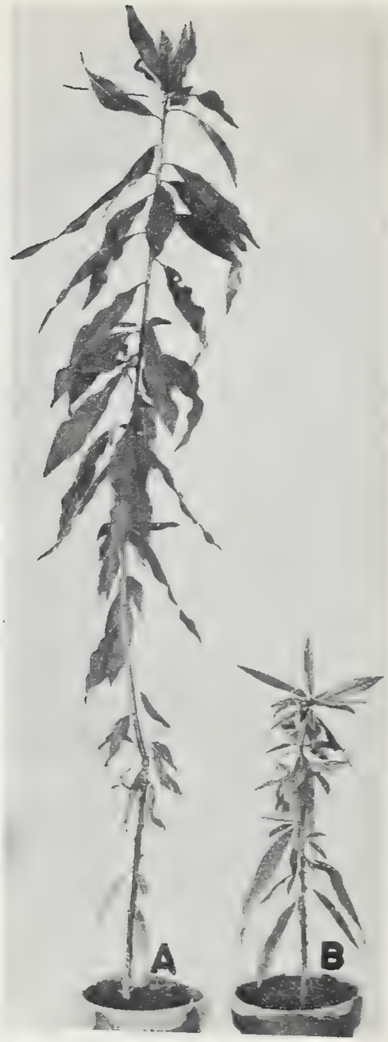


FIGURE 28. Symptoms in peach seedlings of cherry yellows strains: (A), strain 2 with practically normal growth except for mosaic leaf symptoms on terminal leaves; (B), strain 1, showing dwarfed and rosetted growth. (Photographed November 14, 1941, three months after inoculation).

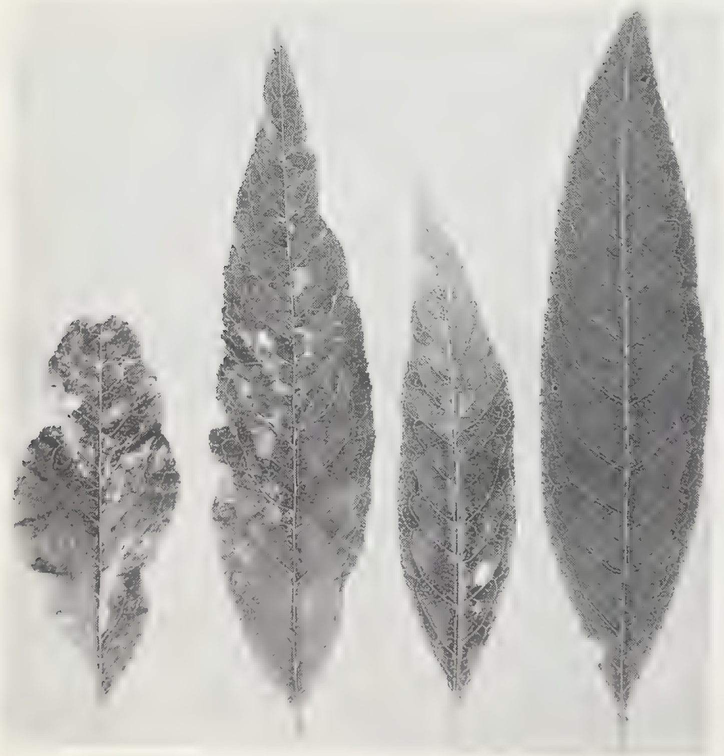


FIGURE 29. Striking mosaic patterns manifested by the cherry yellows strain 2 virus in leaves at certain stages of peach seedling development, otherwise normal except when growth stops or is retarded.

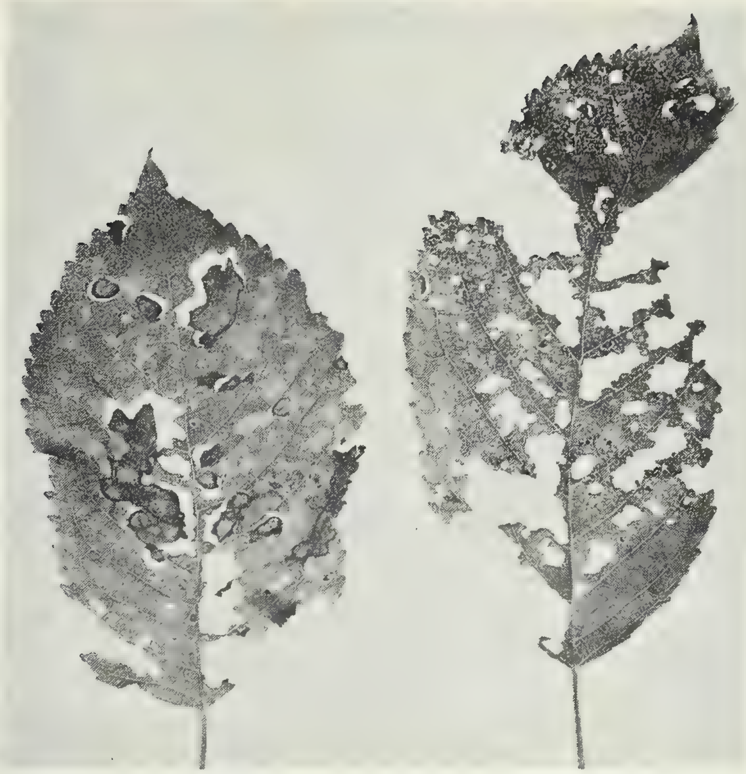


FIGURE 30. Extreme tatter leaf symptoms on Black Giant sweet cherry.

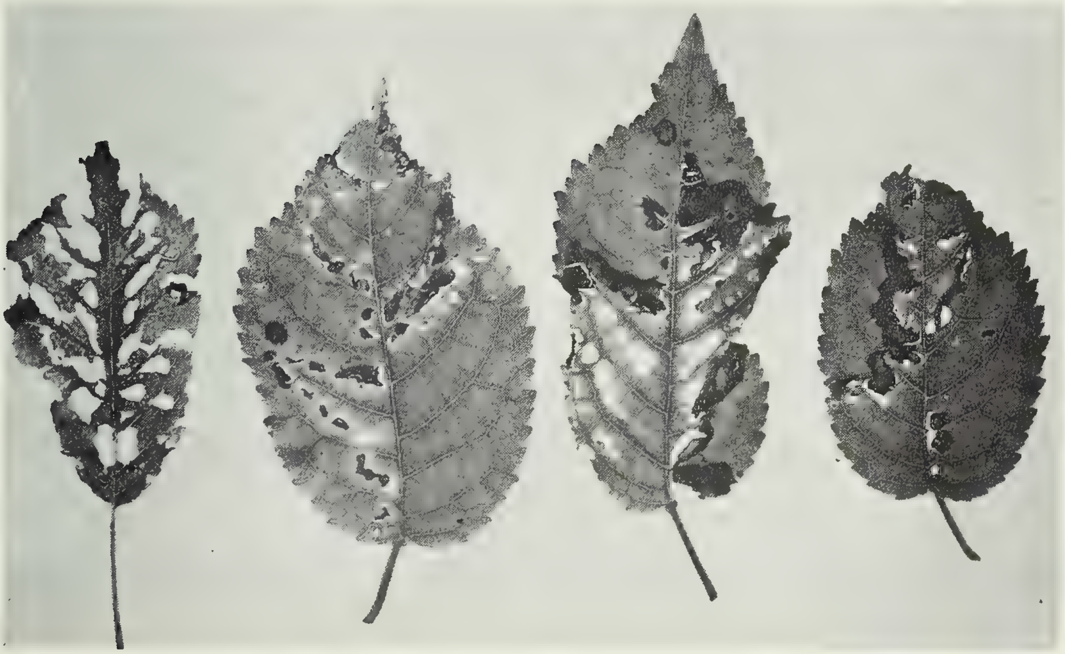


FIGURE 31. Severe tatter leaf on Black Tartarian sweet cherry.

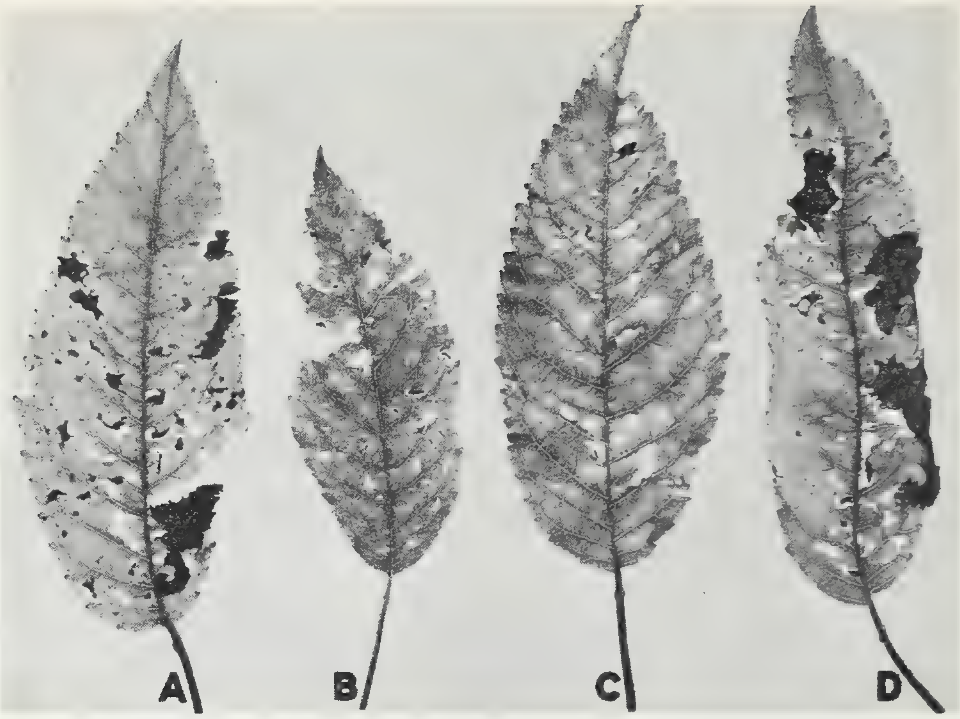


FIGURE 32. Sour cherry necrotic ringspot showing leaf symptoms induced on Black Tartarian sweet cherry employing budwood from Yellow Spanish sweet cherry (A) and Montmorency sour cherry (B, C, D) in three different experimental orchards. Photographed July 6, 1942.

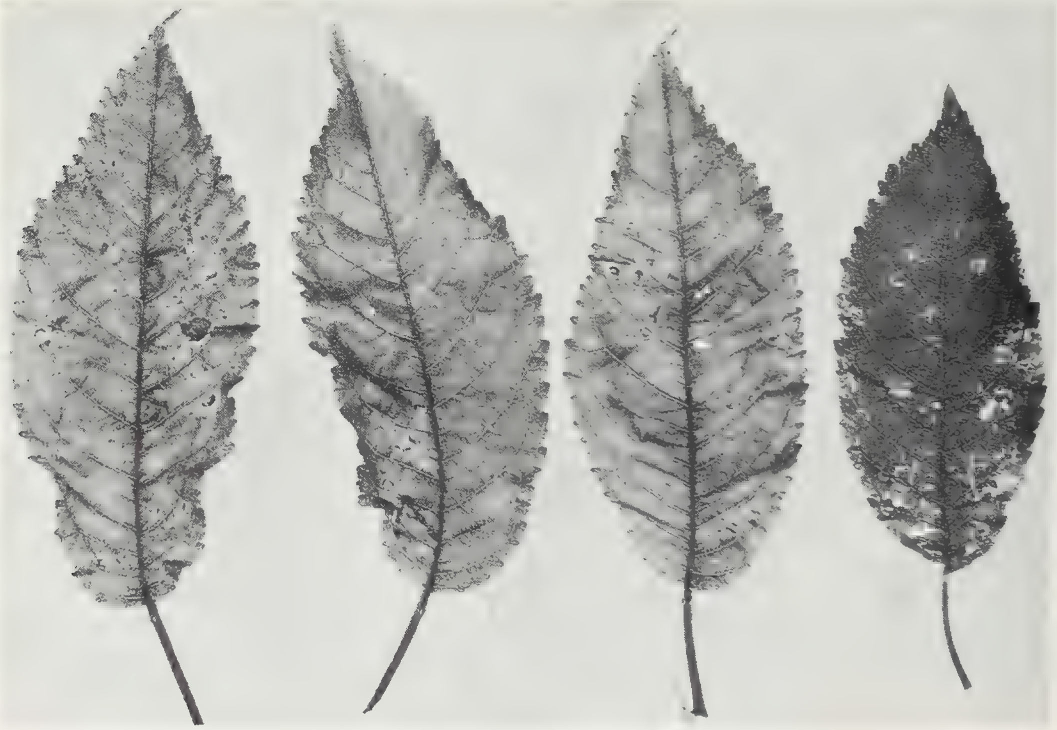


FIGURE 33. Sour cherry necrotic ringspot foliage symptoms on Napoleon sweet cherry induced by budding from masked Montmorency showing reddish to purple bordered ringspots, some of which later became necrotic. Photographed July 6, 1942.

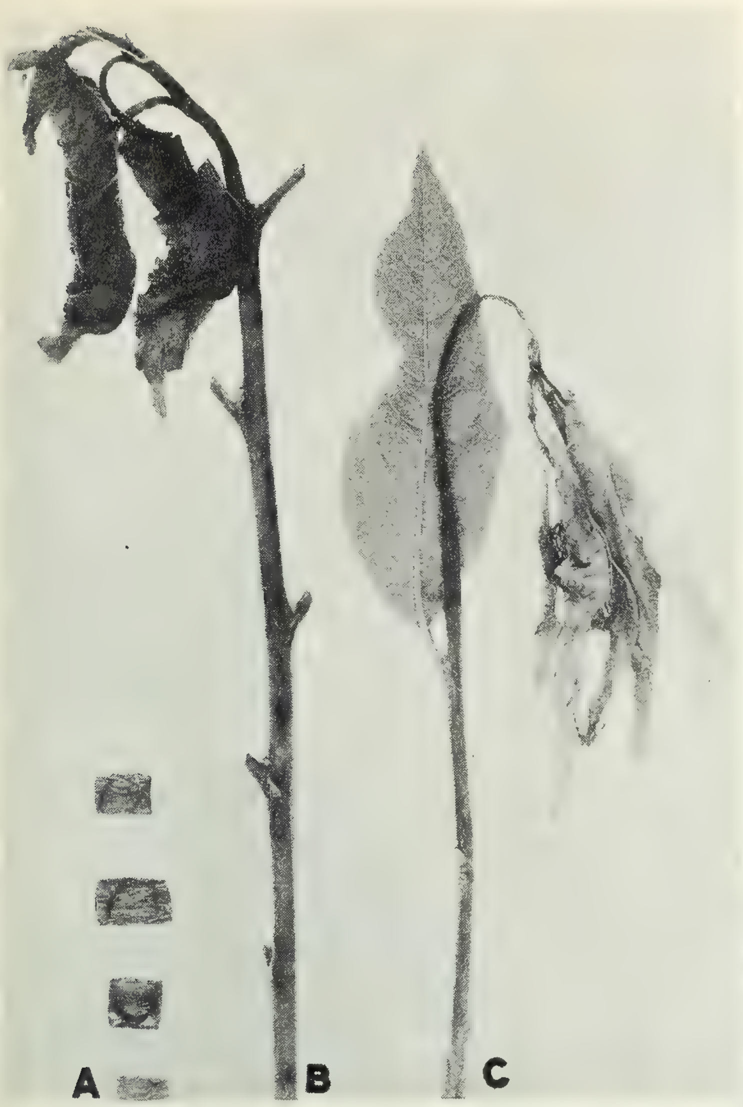


FIGURE 34. Bark symptoms on Napoleon sweet cherry and Rochester peach (A) Bark blisters taken from trunk of Napoleon cherry; (B) dieback and stem canker on Napoleon shoot; (C) stem cankers and dieback on Rochester peach. All caused by sour cherry necrotic ringspot. Photographed July 6, 1942.

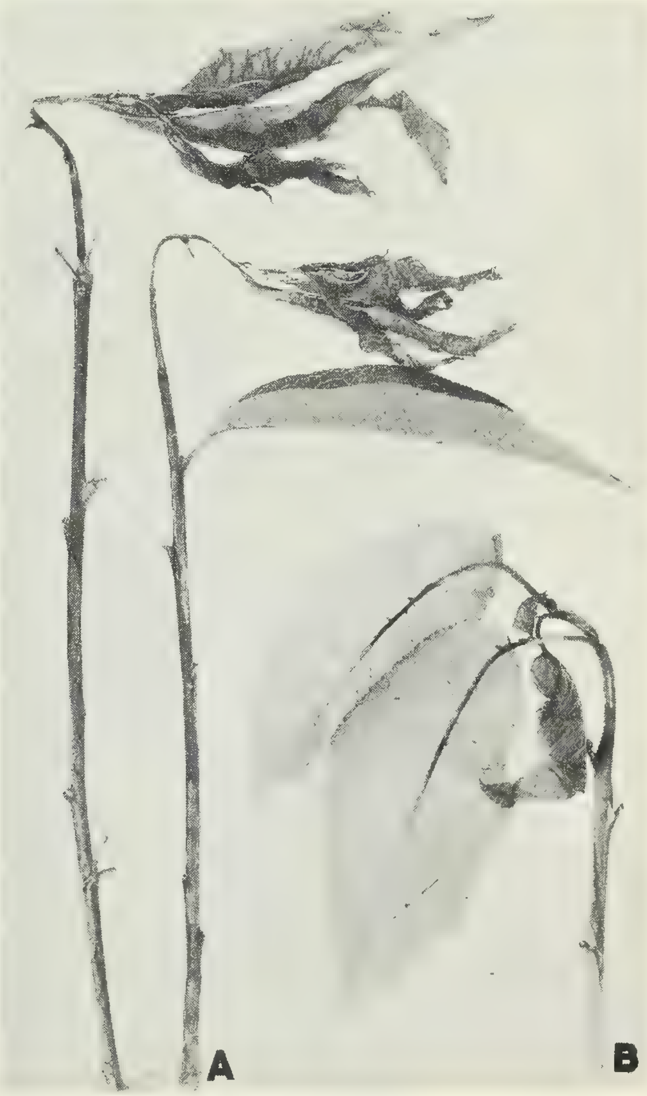


FIGURE 35. Sour cherry necrotic ringspot, necrotic symptoms (cankers and dieback) on Rochester peach (A), and on Black Tartarian sweet cherry (B). Photographed July 6, 1942.

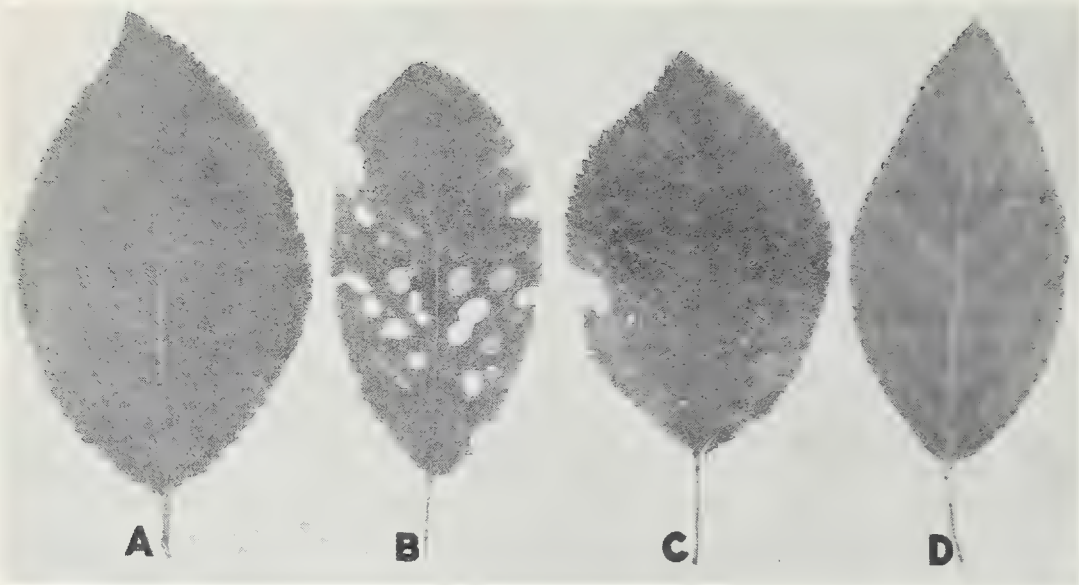


FIGURE 36. Foliage condition on Lombard plum (A), Italian prune (B), Bradshaw plum (C), and Shropshire Damson (D) resulting from grafting from Lombard which contained a latent virosis. Only Italian showed severe necrotic spotting. Bradshaw developed tiny necrotic spots.

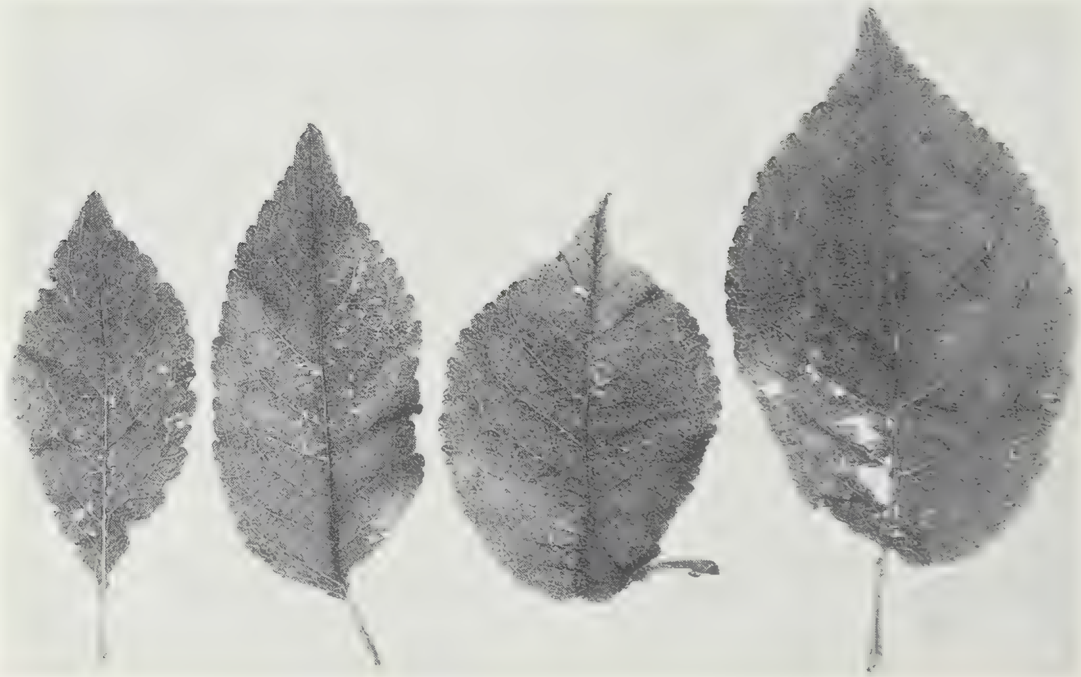


FIGURE 37. Prune dwarf foliage symptoms induced on Montmorency cherry showing dark and light green rings and distortion and partial recovery.

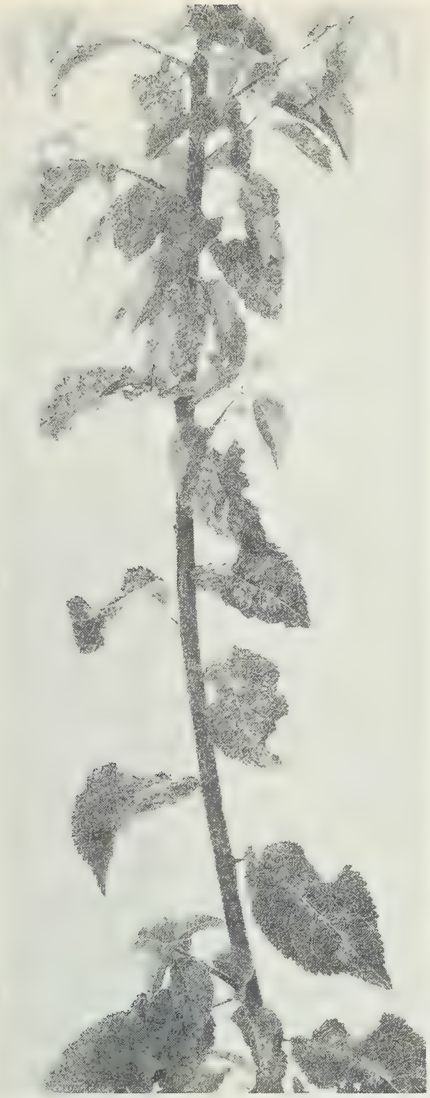


FIGURE 38. Chlorotic ringspot and distortion, identity undetermined, on myrobalan plum seedlings used as rootstocks for plums.

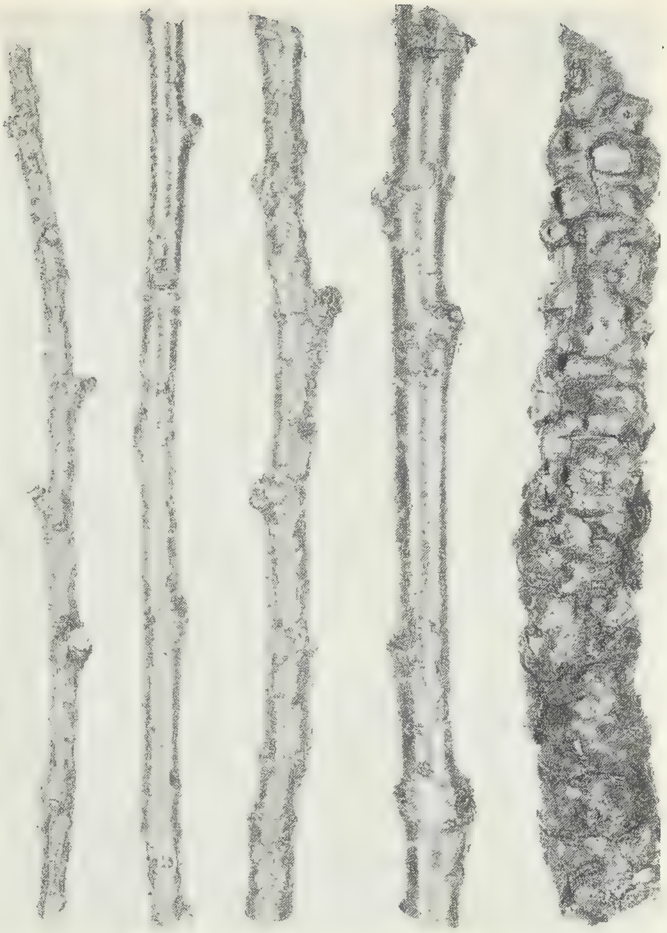


FIGURE 39. Rough bark condition on flowering cherry of unknown identity received from Mineola on Long Island and photographed April 5, 1937.

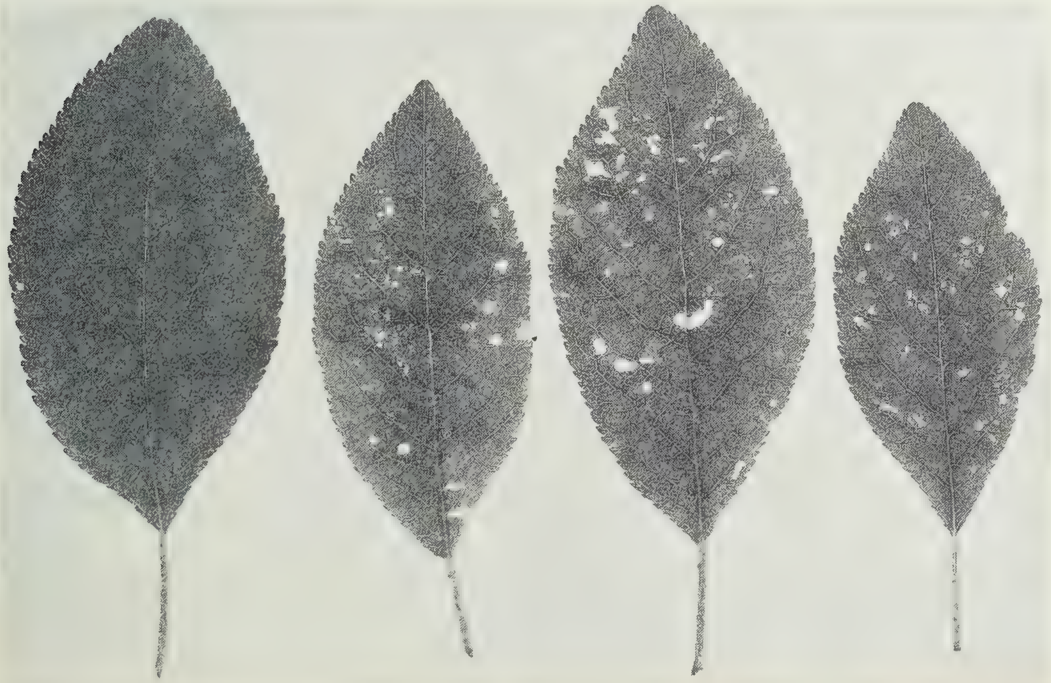


FIGURE 40. Foliage symptoms of Lombard plum latent virosis on Stanley prune, consisting of leaf spot and shot-hole about one year after grafting. Photographed April 11, 1944.

Bloom is delayed and few fruits are set. Rosetted trees also frequently contain ringspot virus, based on indexing tests.

Mottle of Sour Cherry: Two kinds of mottle conditions have been observed on sour cherries. One mottle becomes pronounced as the fruits progress toward maturity. Montmorency foliage (Figure 13) shows a very unusual type of chlorosis with a greenish yellow background peppered with green specks. An abnormal fruit condition associated with this foliage condition was under observation for five years; the cherries were pale red or pink in color and with firm flesh comparable to that of sweet cherries but low in sugar and insipid. The fruits were otherwise normal in size and shape. Symptoms were observed only on Montmorency in Niagara County on Mazzard roots. Induced symptoms on peach seedlings were very mild; however, older leaves became mottled, turned yellow, and fell to the ground.

The second mottle condition was observed for four years early in the growing season in a Montmorency orchard on Mazzard roots in Monroe County. Foliation was delayed with the small early-formed leaves mottled and distorted. The poor fruit-set was due in part at least to poor pollination weather. Symptoms and indexing showed that a small percentage of trees had ringspot virus.

Tatter-Leaf: The so-called tatter-leaf (shredded-leaf, lace-leaf, etc.) is essentially a ringspot disease (possibly identical to ringspot of sour cherry). Ringspots develop early in the season and the spots drop out to form the shothole condition. It is significant that practically identical symptoms result whether the inoculum comes from affected Yellow Spanish sweet cherry or Montmorency sour cherry trees. The sequence starts out with chlorotic ringspots followed by necrosis and shothole (Figure 14). The effect on fruit set is illustrated in Figure 15. Late season (mid-September) symptoms are shown in Figure 16. Affected trees may be masked in whole or in part, after the initial shock symptoms (81). This disease causes reduced yields and shortens the tree life span by making it more subject to winter injury. The foliage on P. avium roots, whether as seedlings in the nursery, as rootstocks in sweet cherry orchards, or as rootstocks in Montmorency orchards, shows practically identical symptoms. Symptoms have been observed on sweet cherry varieties Yellow Spanish, Napoleon, Black Giant, Black Tartarian, Windsor, and Stark's Gold, and on Mazzard seedlings. Practically identical symptoms have been observed on large P. avium trees in the vicinity of cherry orchards (Figure 17).

Sweet Cherry Mottle: The mottle disease (Figure 18) is characterized by a chlorotic mottling of the foliage usually not accompanied by necrosis and shothole except when mixed with the tatter-leaf virus. It can be distinguished from tatter-leaf, just as yellows is readily distinguished from ringspot in Montmorency, by indexing on Italian prune (see below, Indexing on Italian prune etc.). Mottle occurs relatively infrequently in sweet cherry and therefore is of minor economic importance.

Crinkle: Leaf crinkle symptoms have been found associated with the Mazzard rootstock in the Northeast (Figure 19). It appears to be a genetic condition, being seedborne and bud-perpetuated, but not bud-transmissible. Crinkle has been observed in seedlings grown under controlled conditions in the greenhouse, in nursery plantings, and also on sprouts growing up from the Mazzard rootstocks of sweet cherry and Montmorency cherry trees in orchard plantings. Relatively few seedlings, 5 percent or less, show symptoms. A crinkle symptom has been observed in certain sweet cherry varieties in commercial plantings in the Pacific Northwest, where it occurs on the scion variety and is probably a distinct disease.

SELECTED INDEXING EXPERIMENTS

Indexing Cherry Viruses on Montmorency: The indexing experiments, conducted principally in the greenhouse and employing the dormant grafting technique, proved extremely reliable for demonstrating the presence of the common ringspot virus whether or not in mixture with the yellows virus. In small dormant one- or two-year-old cherry trees at the begining of the greenhouse growing season, symptoms of ringspot regularly appeared on the first new growth and usually within 10 to 18 days from grafting. Ordinarily the graft scions grew also and these were invariably symptomless for ringspot. Figure 20 illustrates the symptomless character of the scion growth when indexed from an orchard Montmorency tree (A) and a Mahaleb rootstock tree (B) previously inoculated and infected with ringspot virus from an orchard tree. It should be noted that the inoculated Montmorency tree developed striking shock symptoms followed by symptomless growth upon recovery. Necrotic leafspot and terminal dieback, and the symptomless growth following these severe shock symptoms are illustrated in Figure 21. Similar but not exactly identical symptoms were produced in Montmorency by indexing with tatter-leaf from sweet cherry.

It was possible to index unknown materials to small cherry trees early in the growing season by bud inoculation accompanied by pruning and extra fertilization to induce new growth. However, this method was impractical. Instead, emphasis was given to the rapid transmission indexing technique employing peach seedlings.

Indexing Sour Cherry Viruses on Peach Seedlings: Peach seedlings and the Elberta and Rochester peach varieties appear to be about equally susceptible to the cherry yellows and ringspot viruses, according to numerous indexing experiments.

Ringspot -- The considerable variability in expression of cherry ringspot virus symptoms on peach seedlings even in very uniform groups of seedlings, indicated the existence of several strains of the ringspot virus, ranging from severe to mild. How definite and stable these apparent strains might be was never ascertained. However, in a few recorded instances, severe strains seemed to maintain their severity and weak strains their mildness. The most severe strain induced a bark canker illustrated in Figure 22, with a more advanced stage in Figure 23. Note that many leaves have been dropped and the stem has been girdled except for a very narrow strip of the bark.

Ringspot and Yellows -- Note the typical stunting and rosette condition of seedling peach trees and the early appearance of symptoms in Figure 24 which compares yellows and ringspot three weeks after inoculation. The contrast in symptoms is even better shown in Figure 25 where at about three weeks after inoculation the ringspot virus has caused the drooping of leaves from death of the stem (dieback). Figure 26 shows a comparison of early stage symptoms on peach seedlings: at A, dieback and symptomless new growth for ringspot, B, stunted, erect, rosette type of growth for vein-clearing rosette virus, and C, typical rosette for yellows. The vein-clearing rosette virus produced the greatest stunting of peach seedlings, as well shown in this illustration.

Yellows -- Figure 27 illustrates the leaf spot symptoms one month after inoculation produced on Elberta peach by indexing from an affected orchard Montmorency tree. Chlorotic rings followed by necrosis and shothole occurred on the first-borne leaves. Later leaves were symptomless for spots but developed into rosettes.

There is evidence for the existence of strains of the yellows virus in Montmorency cherry (32). Figure 28 shows two peach seedlings three months after bud inoculation: B dwarfed and rosetted as is typical for strain 1 of cherry yellows virus, and A with practically normal growth except for mosaic symptoms on terminal leaves as growth stops. The character of the mosaiced peach leaves is illustrated in Figure 29. Because it has been obtained when indexing peach seedlings with buds from certain orchard trees affected by yellows, this reaction is considered diagnostic of what has been called strain 2 of the cherry yellows virus. The puzzling fact about this strain is that striking mosaic patterns along with some dwarfing and distortion are most likely to appear at occasional times when growth is checked. Otherwise the growth will appear normal. In preliminary work these symptoms appeared only when the temperature was low. Because of inability to control greenhouse temperature this study was postponed indefinitely.

Indexing Cherry Viruses on Sweet Cherry: Every sweet cherry orchard mapped contained tatter-leaf disease, but only occasionally were mottle symptoms observed. In several instances both diseases occurred in the same trees.

Tatter-leaf symptoms were observed on and in every case reproduced by indexing from P. avium, including the varieties Napoleon, Yellow Spanish, Black Tartarian, Windsor, and Stark's Gold, and Mazzard seedlings. Figures 30 and 31 show severe symptoms on Black Giant and on Black Tartarian, respectively. Compare these illustrations with Figure 32 which shows sour cherry necrotic ringspot symptoms (B, C, D) on Black Tartarian compared with Yellow Spanish sweet cherry strain (A), and Figure 33 of sour cherry necrotic ringspot on Napoleon.

Figure 34 shows severe terminal dieback and stem canker on Napoleon sweet cherry (B) and Rochester peach (C) indexed with sour cherry necrotic ringspot. The bark blisters taken from the trunk of Napoleon (A) would later develop into cankers. Figure 35 illustrates necrotic ringspot symptoms (cankers and dieback) on Rochester peach (A) and Black Tartarian cherry (B). The virus source was a light-bearing, completely masked Montmorency.

Indexing on Italian Prune and Lombard Plum: When Lombard plum was indexed on three other plum varieties, a latent virosis was revealed (Figure 36) on Italian prunes. Comparative studies with the prune dwarf virus, ten different cultures of the sour cherry yellows and ringspot viruses alone or mixed, two cultures of the sweet cherry chlorotic spot or mottle virus, and two cultures of the sweet cherry tatter-leaf virus, demonstrated that strain 1 of the sour cherry yellows virus and the sweet cherry chlorotic spot or mottle virus produced symptoms simulating prune dwarf on Italian prune and Lombard plum. When indexed back to Montmorency cherry the yellows strain of prune dwarf reproduced typical yellows symptoms whereas yellows developed on only one of three trees receiving the cherry mottle strain of prune dwarf. Unfortunately this work was terminated before the relation between these two strains was worked out.

When true prune dwarf virus was indexed on Montmorency cherry an unusual symptom pattern developed, as shown in Figure 37, consisting of chlorosis, distortion, and some necrotic spotting. The complete story here also was unattained.

Other Plants Tested for Indexing Hosts: A chlorotic leaf spot symptom was observed on chokecherry (Prunus virginiana) in fence rows in New York and in Wisconsin in 1940. This diffuse chlorotic condition was reproduced by grafting chokecherry with scions or buds from diseased sour cherry. These symptoms were found to represent the ringspot virus of the complex. The fact that some symptomless chokecherry plants mask the ringspot virus is evidence that the chlorotic ringspot phase is the "shock" phase of the disease, showing only for a period after inoculation has taken place.

The pin cherry (P. pensylvanica) has been observed in fence rows with a chlorotic symptom pattern. These symptoms were mild and varied somewhat from plant to plant and were similar to those following inoculation under controlled conditions in the greenhouse. Both symptomed and symptomless trees have been observed adjoining diseased cherry orchards.

The rum cherry (P. serotina) has been occasionally observed with a reddish yellow symptom pattern but has never been found susceptible to any of the sour or sweet cherry viruses.

The Mazzard cherry (P. avium) ordinarily does not produce symptoms when bud-inoculated with the yellows virus, but is very susceptible to ringspot.

The Mahaleb cherry (P. mahaleb) may sometimes show a chlorotic stipple spot or a chlorotic ringspot and line pattern. The former seems to be associated with cherry yellows and the latter with cherry ringspot. At other times no symptoms may show or recovery may follow mild symptoms.

Doubtful symptoms were sometimes induced on myrobalan plum (P. cerasifera) following inoculation with cherry viruses. Figure 38 is a chlorotic ringspot or asteroid spot condition rather prevalent on myrobalan rootstocks. Its true identity has not been ascertained.

TRANSMISSION STUDIES

The first transmission experiment was started in the spring of 1935 in a special planting principally of Montmorency trees donated by Dansville nurserymen. In 1934 approximately 100 trees were planted, spaced about 4 feet apart in rows 6 feet apart. Ten dormant scions, taken from orchards that had been mapped for disease incidence, were grafted into 20 trees in late April 1935, just as growth was beginning. Later, as yellows symptoms were appearing in the mapped orchards in the severe yellow leaf drop year of 1935, budsticks were collected and indexed by budding into 20 additional trees. Thus a total of 40 trees was inoculated. No symptoms were observed during 1935. In late June 1936 observations revealed positive yellow leaf drop symptoms on 12, or 30 percent, of the inoculated trees. Of the 40 uninoculated check trees, two showed positive yellows symptoms with abundant leaf drop and two others were labeled as diseased although only a small number of yellow leaves developed. The presence of symptoms on the check trees was indeed confusing. Owing to unforeseen circumstances this young experimental planting was moved to a new location in early July and practically all of the trees died from the shock of moving. This misfortune prevented making further observations on graft transmission results and the experiment was lost.

Because of the presence of yellows trees among the check trees in this experiment several nurseries were visited in 1937, 1938, and 1939 to determine whether the disease was present and originated in them. In 1937 and 1938 the presence of a considerable amount of fungus leaf spot obscured the yellows symptoms although some healthy (fungus-free) locations showed occasional two-year-old trees with yellow leaf drop.

The question as to how the nurseries acquired the disease in the first place remained unanswered until the following year. Most nurserymen maintained budwood sources in their own plantings from which the propagating materials were taken in August or early September each year. With one exception this was the type of planting visited until 1939. In the one exception it was found that budwood was obtained from a cherry grower. It was learned that certain large cherry growers were supplying certain nurseries with budsticks from their orchards to be grown on contract for them. Visits to these nurseries in 1939 revealed abundant symptoms. Thus the disease was unwittingly introduced into the nurseries from orchards and then returned to the growers' new plantings which explained why large commercial orchardists usually experienced greater trouble. Some of the newly planted orchards employing such materials were mapped and used in subsequent studies on incidence, spread, and multiplication of the cherry virus complex.

Greenhouse transmission studies on cherry yellows during 1937 and 1938 were disappointing because symptoms were not produced in the greenhouse. When trees inoculated in 1937 failed to produce symptoms in 1937 or 1938 it was decided to transplant these trees to the outdoor test planting in 1938. Thus it was discovered that over 70 percent of the bud-inoculated trees of 1937 and 1938 were showing symptoms in 1939 and that the transmission technique was not at fault.

Starting in 1939 numerous transmission studies were conducted both in the greenhouse and in the field on the virus complex in sour cherries, employing mainly the Montmorency variety.

In 1940 a comparison was made of the field symptoms on cherries and other stonefruits during late June and early July in New York, Ontario, Michigan, and Wisconsin. In the important particulars the symptoms were essentially identical in all the locations. For verification propagating materials were obtained from some locations for comparative studies under controlled conditions in the greenhouse at Ithaca, New York.

Comparative Interstate Transmission Experiment: A graft transmission comparative study was started in January 1941 employing four sour cherry bud sources from Wisconsin, five from New York, and two from Michigan. Three graft inoculations, each consisting of two scions per tree, were made on February 10 from each source to individual Montmorency trees. Striking "shock" ringspot symptoms were showing on all but six of the 33 trees employed within 12 to 24 days after grafting. As was to be expected no yellows symptoms developed in the greenhouse because of the prevailing temperatures (68^{o} F. or above). While in a good growing condition the trees were transplanted to the field on May 22, 1941 with two trees developing yellow leaves on June 6. A year later final field observations were made on yellows symptoms with the result that all four Wisconsin sources, one Michigan source, and three New York sources involved the same diseases.

Samples of the same source materials for the comparative study were bud-indexed on small Elberta peach trees on March 6, 1941, employing two trees for each sample. Chlorotic and necrotic ringspot were observed on some of the youngest peach leaves but otherwise the plants were relatively symptomless the remainder of the growing season. In a later check the symptom-showing trees developed rosette, indicating that the ringspots were an early stage of cherry yellows symptoms which developed the following year.

On April 23 another greenhouse transmission experiment was conducted employing the same cherry bud sources from Wisconsin, Michigan, and New York, and budding each source in triplicate from dormant cherry to peach seedlings. Seven days after budding the peach seedlings were topped back to the diseased bud about midway on the stem to stimulate a new spurt of growth. Symptoms were showing on May 18 or 18 days after the shock treatment. It is of interest that all of the bud sources that produced ringspot symptoms on cherry induced dieback and sometimes bark canker on peach seedlings. Also, all of the sources that induced yellows on cherry produced a stunting and rosette on peach seedlings. This is strong evidence that the rapid transmission technique (Hildebrand 23), involving topping, speeds the appearance of symptoms and aids in evaluating orchard trees for suitability as bud propagating sources for nursery plantings in the same season.

The symptoms on peach seedlings, while speeded by topping, were not so well defined as those on Montmorency sour cherry. Dieback usually indicated the presence of ringspot virus and rosette of the yellows virus, but some peach seedlings showed no symptoms after indexing and topping. Also, following the shock phase of ringspot the seedlings were symptomless. The presence of virus strains and the existence of variability in the seedlings themselves could account for variations in degree of severity of expression. It is significant, however, that all of the sources except one gave positive results by indexing on peach and correspond to the graft-indexing results on Montmorency cherry in all other particulars. Moreover, the rapid transmission technique for yellows gave results within a month whereas nearly a year longer was required to complete the experiment on cherry.

As an example of the regular transmission experiments, on April 21, 1941, 11 cherry tree bud sources from mapped orchards were indexed on peach seedlings in triplicate and one week later were cut back to the diseased bud insertion. From all sources except one, two kinds of symptoms had usually developed within one month's time. The symptoms were dieback and rosette or a combination of them. Tentatively the rosette was interpreted as a symptom of yellows and dieback as a symptom of ringspot. This was the technique employed to demonstrate the presence or absence of virus in orchard cherry trees to be employed for propagating purposes in the nurseries.

Many such routine experiments were conducted in an attempt to refine the method and improve its reliability, especially when checking for certification of any materials to be employed in nurseries. A confusing element has been the considerable variability in symptoms, which suggests strain differences in the viruses, from severe to very mild or symptomless. A problem posed from the beginning of this study was the separation of yellows from ringspot. Numerous experiments have revealed no reliable selective host. Although Italian prune indexes for yellows and not for ringspot, it was not determined whether ringspot virus had been eliminated, but this is a possibility for investigation. The fact that sweet cherry mottle when indexed on Italian prune also produced small strap-shape leaves suggests a relationship to sour cherry yellows (36). Known cases where cherry yellows failed to induce rosette on peach seedlings, while parallelling the failure of Montmorency to produce yellow leaf symptoms at temperatures above 65° F., also gave supporting evidence for a strain 2 of the yellows virus with which growth is normal except at low temperatures when mosaic symptoms occurred. The frequent association of ringspot with yellows still leaves us with no means of separation to date. It is easy to find orchard trees with only ringspot symptoms, but extremely difficult to locate a tree showing only yellows symptoms and be certain that yellows is the only virus present. Two trees located over a period of five years, when indexed on Montmorency cherry or seedling peach, never gave evidence of ringspot virus presence. However, the possibility remains that a mild masked ringspot could have been present and undetected. Also there was the possibility that a strain of ringspot may be an essential component of yellows.

EFFECT OF TEMPERATURE ON YELLOWS SYMPTOMS

Sour cherry trees receiving buds from infected orchard trees in 1938 developed yellow leaf drop symptoms on only a few leaves in the coolest greenhouse. During May these trees were transplanted to a test planting for further observation and to check on the transmission technique. No further symptoms developed during 1938.

To further check on temperature the 1939 transmission experiment employed 24 Montmorency trees graft-inoculated with yellows scions in late January with one-half of the trees being placed respectively in the cool (about 65° F.) and warm (above 70° F.) sections. Ringspot symptoms developed on the new growth in both sections but yellows failed to develop in either place except for possibly a trace (1 and 2 leaves partly yellowed) on two trees in the coolest location. Here again the trees were transplanted to the test planting where no further symptoms developed in 1939. A similar experiment was repeated in 1941, using 20 small graft-inoculated trees, with similar indefinite results for yellows symptoms in the greenhouse. By transplanting the trees to the experimental field planting for subsequent observations evidence was obtained to help clarify the temperature effects. The significant fact was the development of typical yellows symptoms outdoors the year following transplanting in late May of the respective years. The fact that ringspot developed symptoms irrespective of temperature was evidence that the yellows and ringspot symptoms represented two distinct virus entities. Another angle is that yellows, by virtue of its longer incubation period, would not show symptoms during the interval under test.

The parallelism observed between currant mosaic and cherry yellows viruses deserves investigation. In red currant the mosaic (yellows) was masked at ordinary greenhouse temperatures (above 68° F.). This was discovered when transmission tests were attempted in the greenhouse in 1939-40. However, this masking revealed the presence of ringspot symptoms never visible on currant when mosaic was showing. It was further determined that the currant ringspot virus was mechanically transmissible, representing the first natural source of tomato ringspot virus (tobacco ringspot No. 2) ever determined. As the result of the successful mechanical transfer of a ringspot virus from the perennial woody currant to herbaceous plants (22, 42), mechanical inoculations were attempted from tender unfolding ringspotted Montmorency cherry leaves to Turkish tobacco, tomato, muskmelon, peppers, cowpeas, aster, and beans; in all cases with negative results. This experiment was repeated in 1942 on the same plants, except beans and cowpeas, but with negative results.

The subsequent report by Moore et al. (61) of the successful mechanical transmission of cherry virus to cucumber is of great significance in this connection.

Keitt and Moore (51) and Moore and Keitt (63, 64) demonstrated a masking of yellows symptoms when trees that received diseased buds were held at high temperatures. They observed yellows symptoms freely expressed in the bud-inoculated trees held in the greenhouse at 16° C. (60.8° F.), whereas practically no symptoms developed at 20° C. (68° F.) and above. Their results suggest a partial to complete masking of yellows symptoms above 61° F. These reports clarified the role of temperature in yellow leaf expression.

Mills (58) reported the relation between prevailing low and high temperatures and the variable expression of yellows symptoms observed in orchards in the State of New York. His data suggest that the chief factor governing the expression of yellows symptoms in the orchard during the growing season is the temperature which prevails during the 30-day period following the petal fall stage. Thus symptoms are more liable to appear when the bloom comes early in the season. Incidentally, symptom expression seems independent of the temperatures that prevail after yellows symptoms first appear, of the amount of rainfall, and of the incidence of cherry fungus leaf spot. Mills states that no data he had available proves or disproves spread of cherry yellows virus after the young trees are set in the orchard.

EFFECTS OF FERTILIZATION AND PRUNING ON VIRUS INFECTED MONTMORENCY

Starting in 1934, before the nature of cherry viruses was known, one large cherry grower in consultation with the writer adopted the practice of extra fertilization to correct the imperfect growth and poor productivity of many so-called winter-injured trees in one large Montmorency orchard. The supplementary fertilization experiment was discontinued at the end of eight years, in 1941, because yields could not be increased thereby (39). The defective trees decreased in yield each year and many which fell below the productive level for profitable yields were removed. Occasional new trees receiving the treatment conformed to the usual experience of decline in vigor with time after infection. Besides yellows and ringspot, which were present in a large majority of the trees, there were nine trees with green-ring yellows and two non-bearing trees with rosette.

Heavy pruning likewise produced no benefits. Dehorning of 20 of the severely diseased unprofitable trees stimulated new growth which was even less productive than before pruning.

Incidentally, a complicating factor of scorch and bronzing of the foliage was also encountered in the orchard over a period of years. Certain marked trees that received muriate of potash (at 4 lb. per tree) starting in 1941 showed a very significant decrease in these symptoms in the second season when the trees received a second application of this same material. By the time the third application would have been given the symptoms had practically disappeared, making it unnecessary. No effect of this treatment was noted on the virus symptoms since the potassium-deficiency symptoms usually occur in July and August and are separated by many weeks from ringspot symptoms in May and yellows symptoms in June.

According to Rasmussen and Cation (72) sprays, fertilizers, and cultural practices had no visible effects on virus diseases of sour cherries. Cain and Parker (7) presented evidence from one sour cherry orchard growing in sod that trees receiving 15 lb. ammonium sulfate annually for three years compared to those receiving 5 lb., at different degrees of virus severity, showed some improvement in growth, fruit set, and yield. The fact that a treble dose of nitrogen proved of benefit on a grass sod suggests that the 5 lb. dose was below the optimum for good tree growth, rather than of benefit in reducing the virus effects.

ECONOMIC IMPORTANCE

Cherry yellows is the most conspicuous and probably the most economically important virus disease of sour cherries in Northeastern United States. Judging from a survey made in 1940 it and ringspot are apparently well distributed in commercial plantings, affecting as many as 90 percent of the trees in the older orchards in New York, Michigan, and Wisconsin at that time.

Yield records have been kept in a number of orchards for at least three years. The age of tree is of primary importance in relation to yields. Young trees infected on or before transplanting to the orchard ordinarily will never produce profitable commercial yields of fruit, therefore such trees should be eradicated or removed immediately. Moreover such trees also serve as reservoirs of the virus facilitating new infections. Moore (60) and Rasmussen and Cation (71, 72) reported on the adverse relation of sour cherry yellows to yield.

In an orchard in Wayne County yield records were taken on Montmorency trees on Mazzard roots, selected to represent four stages in yellows development: ? healthy (trace of symptoms), mild symptoms, moderate symptoms, and severe symptoms. Good representative material was located in 15 out of 48 rows in the orchard and yields were kept over the three-year period from 1941 to 1943. The results show average yields as follows: ? healthy 932, mild 76.8, moderate 50.2, and severe 37.9 pounds. It should be borne in mind that a large factor in the reduction of yields was the ringspot virus in many of the trees, which intensifies the devitalization effects from yellows.

An orchard in Orleans County was selected to illustrate Montmorency on Mahaleb roots: it was the most productive orchard encountered in the State, with some trees producing over 500 pounds in 1942. It was relatively free from complicating troubles such as winter injury, poorly drained soil, or lack of uniformity of soil, but had a mild form of ringspot expression on a number of trees. Because of such uniformity one row of 27 trees served as a cross-section of the orchard. Relatively symptomless trees used as checks were compared with others showing slight to heavy leaf drop in the early, medium, and advanced stages of disease. Some of the trees were showing heavy leaf drop for the first time whereas, at the other extreme, heavy leaf drop had been noted for about five years previously. The latter trees were beginning to show the type of growth characteristic of the advanced stage of disease with practically all of the fruit borne on the previous season's terminal growth.

Table 2 gives the yields, fruit size, and soluble solids of the fruits on four comparable trees showing trace, mild, moderate, and severe yellows symptoms in 1942. It is doubted that the slightly greater total soluble solids for the diseased trees was significant especially since the fruit color suffered somewhat and ringspot virus was frequently present though masked.

Table 3 gives the yields of ten trees in five different yellows disease classifications in two other rows of the same orchard selected because all groups were represented. Also, some of the trees in all the classifications contained ringspot virus almost if not completely masked. This partly explains why trees recorded as healthy showed yields ranging from 215 to 502 pounds and comparable ranges for the other classifications. Upon indexing it was found that selected lower yielding trees showing only a trace or mild yellows symptoms invariably contained ringspot. Also, yearly fluctuation in the severity of yellows symptoms proved to be the case in this orchard. The most significant feature about this orchard was the vigor and productivity of the trees on an ideal cherry soil which was well drained and fertile.

The only other Montmorency orchard on Mahaleb roots that gave comparable high yields is located in southern Michigan.

STONE FRUIT VIRUS DISEASE CONTROL

Nursery Control: The single expedient of employing only inspector-approved budwood has enabled New York nurseries to supply the trade with trees containing a very low percentage incidence of disease from the very beginning of the program in 1939. The nurserymen took pride in cooperating with the inspection service and with the college and immediately ceased to employ propagating materials other than those certified by the State inspectors. Propagating materials from orchards were indexed directly or indirectly at the laboratory or test planting to establish freedom from disease. The test planting in the nursery community financed by the nurserymen was a far-sighted educational move to convince doubting-Thomases of the insurance protection thus afforded. To effectuate this program the inspectors were thoroughly familiarized with symptoms. The small percentage incidence of disease which persisted in young orchards was undoubtedly traceable to the rootstock source of virus. Most of these trees could have been eradicated during the second year of nursery growth by repeated tree by tree inspection. In other words, it was recommended that the nursery plantings be inspected at monthly intervals during the growing season. The most serious stumbling block to such inspection was the frequently heavy fungus leaf drop that masked or obscured the virus symptoms. The nurserymen had this problem well in hand at the time the writer left this work in 1944.

In a few cases the investigator, in cooperation with an inspector, followed developments in a limited number of nursery plantings throughout the season. When individual leaves became creamy white or yellow after the leaf-drop season had passed the trees were labeled for sending to the experimental planting at Ithaca at digging time in the autumn. Thus, in a few cases, the buds in the axils of defoliated yellow leaves were marked and their history followed. Early defoliation weakened the buds making them subject to a type of winter injury in which the bud was killed outright or came through the winter in a very weakened condition (Figure 4). This is why bearing trees infected with yellows virus, where increasing numbers of leaves drop

Table 2. Fruit yields in pounds, fruit size in number of fruits per pound, and percent total soluble solids in a very productive Montmorency orchard on Mahaleb roots. All stages of cherry yellows are represented from a trace to severe symptoms with ringspot present but largely masked.

? Healthy-trace			Trace-mild			Mild-moderate			Moderate-severe		
Yield per tree (lb.)	Number fruit per lb.	Percent soluble solids	Yield per tree (lb.)	Number fruit per lb.	Percent soluble solids	Yield per tree (lb.)	Number fruit per lb.	Percent soluble solids	Yield per tree (lb.)	Number fruit per lb.	Percent soluble solids
293	109	13.2	222	122	18.8	125	90	13.6	91	74	15.8
270	89	14.4	206	84	13.4	148	95	17.6	95	90	15.8
259	100	15.4	223	81	15.4	122	90	15.4	89	89	15.6
286	110	16.6	215	84	15.8	154	89	15.4	90	76	15.2
Average 277	102	14.9	216.5	93	15.8	137.2	91	15.5	91.2	82	15.6

Table 3. Yields of fruits on ten trees in five different yellows disease classifications (same orchard as Table 2).

Disease severity	? Healthy	Trace	Mild	Moderate	Severe
Range in yield[a]	215-502 lb.	176-362 lb.	240-372 lb.	206-299 lb.	90-150 lb.
Average yield	345 lb.	269 lb.	270 lb.	242 lb.	129 lb.

[a] Under "? Healthy" and "Trace" disease classifications the lowest yielding trees had marked ringspot symptoms which was not true for the "Mild", "Moderate" and "Severe" classifications.

prematurely on succeeding years, have their defoliated stems denuded of fruit and leaf buds. Thus trees in an advanced stage of disease will bear fruit almost exclusively on the previous season's growth.

In the case of cherry ringspot virus, before uninspected orchard budwood was prohibited, skips were occasionally observed in nursery plantings. On closer inspection the surviving Mahaleb rootstocks showed leaf symptoms of a line-pattern character (43). Subsequent experiments were conducted, budding Montmorency on some of the diseased Mahaleb rootstocks with fair success. However, reciprocal experiments using diseased Montmorency budwood on healthy Mahaleb consistently resulted in bud failure. It is indicated that Mahaleb rootstock is an obstacle to the introduction of necrotic ringspot into the nursery from orchard sources. When the Mazzard rootstock was employed, however, there was a low but consistent percentage of sweet cherry bud survival. This may explain why the sour cherry suffers more from ringspot when on Mazzard roots.

The eradication of diseased trees from the nursery is the most important control of the cherry viruses (yellows and ringspot). By 1944 this practice was being followed for the fifth year in New York (35) with excellent results.

Since sour cherries are commonly grown for two seasons before digging, the nursery inspectors have two seasons in which to find infected trees. Inspections were started in mid-June and continued at monthly intervals until autumn (September). The value of an extended inspection is most important in the young trees, the first season following budding, because not infrequently first symptoms may be delayed until August, September, October, or even till the second season. Also, not infrequently only one leaf may appear on a given tree during the first season's growth, the chlorosis is more of a cream than yellow, and the leaves persist longer late in the season.

Orchard Control: When the orchard becomes unprofitable there is no alternative to removing all the trees. In the young orchard within two years from planting the recommendation is the immediate removal of all trees showing virus symptoms. According to observations in a considerable number of such orchards planted to trees propagated from known inspected nursery plantings, the incidence of disease was never over 5 percent and usually less. It takes the skill of the investigator or trained inspector to tag the plants for removal. Replants made at this time at a minimum of expense will soon be very close in size and age to the other trees.

The removal of diseased trees in orchards that have reached the unprofitable stage of production and replanting with young healthy trees was tested in one large sour cherry orchard over a period of five years, and unsuccessfully. The results suggest that such a procedure should be discouraged. The young sour cherry replants readily contracted disease, showing the severe symptom stage (yellows) within two or three years, making the small replants practically worthless by fruit-bearing time. Consequently there was no alternative to their removal.

To be profitable bearing trees should average 100 pounds or more fruit per year. The best plan according to most New York growers is to keep the bearing orchard until unproductive and then to pull the entire orchard. According to Rasmussen and Cation (72), if removal is planned it should be on a locality or district basis unless the individual orchard is isolated.

A number of variables are inherent in the cherry industry. New York has no well-standardized strains of Montmorency but Michigan has made progress in this direction (Gardner, 18). There are upright growing trees, the weeping type, and a number of strains falling in between. The virus diseases confuse the picture by influencing the type of growth. Yellows virus alone induces a weeping or tendril type of growth. Ringspot virus induces an upright stubby terminal type of growth. Both viruses stunt the trees; ringspot by reducing the size of leaves and fruits; yellows by denuding leaves while at the same time increasing the size of both fruit and leaves. Certain selections of Montmorency (Rasmussen and Cation, 72) vary in their susceptibility to disease. It is the writer's opinion that the rootstock plays an important role. The propagation of nursery trees from disease-free, highly-productive strains or selections promises to become an important control measure.

The rosette virus never assumes much importance in sour cherry orchards for several reasons. The bloom is delayed and many of the pistils are aborted with resulting small yields. Many growers call such trees "bastards" and promptly remove them.

Admixture of Rootstocks: In New York it was rather conventional horticultural practice to recommend Mazzard roots in soils that were not ideal for the more demanding Mahaleb. When reduction in yield of certain trees was encountered it was argued by some growers that this could be explained by an admixture of roots. That is, the nurserymen had supplied some trees on the Mahaleb rather than Mazzard rootstocks to account for the greatly reduced yields (to

30 percent or less of a crop). To check on the validity of this contention a quick method was employed for determining what kind of rootstocks were present under typically diseased trees.

Tests were conducted in one orchard in June 1941 employing root samples from four relatively symptomless and four yellow leaf trees. All of the roots tested[2] reacted positively to the typical tannin reaction for Mazzard roots regardless of the unthriftiness of the diseased trees. Hence unthriftiness was not correlated with presence of Mahaleb roots but rather with Mazzard roots.

DISCUSSION AND CONCLUSION

The cherry virus complex has been present in cherry orchards in Central and Northeastern United States and adjoining Canada for over 35 years (Stewart, 77). Before and since Keitt and Clayton (48, 49) demonstrated its virus nature numerous studies on stone fruit viruses have been reported including Berkeley (2); Berkeley and Willison (3); Cation (8, 9); Cation and Boyer (12); Chamberlain, Willison, and Berkeley (13); Gloyer and Glasgow (19); Hildebrand (23 to 43, inclusive); Hildebrand and Mills (46); Hildebrand and Palmiter (47); Keitt and Clayton (50); Keitt and Moore (51); Mills (58); Moore (59, 60); Moore and Keitt (62, 63, 64, 65); Moore, Boyle, and Keitt (61); Palmiter and Hildebrand (66); Rasmussen (69, 70); Rasmussen and Cation (71, 72); Willison (80); Willison and Berkeley (81); Willison, Berkeley, and Chamberlain (82); Thomas and Hildebrand (78).

Similar but different virus complexes are also present in other parts of the country on stone fruits -- Blodgett (4); Bodine (5); Clayton (14); Cochran (15); Cochran and Hutchins (17); Lott (52, 53, 54); Richards (75); Richards, Hutchins and Reeves (76); Zeller (83); Zeller, Milbrath, and Cody (84). It is significant that in a relatively short span of years by concerted effort a large number of stone fruit virus diseases could be brought into focus to the point of identification (Hildebrand, Berkeley, and Cation (44); Anon. (1)).

Some would lead us to believe that these virus diseases are new, that somehow they just popped up. All of the viruses discussed here were present when this investigation was begun except yellow-red virosis of peach, for which there is circumstantial evidence that it came from the Orient on an ornamental cherry. Modern horticultural practices have facilitated the spread and dissemination of virus diseases. Some of the new strains of cherries possessed certain fruit and growth characteristics because they harbored viruses. It became a custon to go to orchards for budwood. In some such fashion the promising Chase (Morello type) cherry became completely viruliferous and we witnessed its demise.

In an attempt to get at the root of the so-called "winter injury" problem, experimental Montmorency cherry trees supplied by nurseries were planted at Ithaca in 1934. They were indexed with diseased orchard materials in 1935. The following year yellows symptoms were showing both on the graft-inoculated and the checks. Thus the cherry yellow leaf drop was traced to the nursery source. Visits to fruit nurseries for three successive years (1937-1939) clearly delineated the nursery story; how growers contracted with nurseries to get choice materials propagated under contract. Thus unwittingly the diseases were multiplied. Investigators everywhere soon found that most devitalizing abnormalities in foliage and stem character and in growth vitality were caused by viruses. In testing a new Michigan peach variety a New York nurseryman unknowingly received also a virus disease (24).

The chief obstacle to studying viruses was the mode of transmission and the consequent long incubation periods. Progress was slow until more rapid transmission or indexing techniques were developed (23, 25). Under greenhouse conditions it was possible to propagate almost at will and year-round studies were conducted, especially when employing peach seedlings.

Studies on virus movement (33, 34, 45) was an aid in reducing incubation periods to one month or less, which expedited progress.

Mechanical transmission by Moore, Boyle and Keitt (61) of sour cherry ringspot to cucumber gave further support to the belief that most ringspots are mechanically transmissible (22). Dodder transmission was also given a trial (42), with some success for peach but not cherry viruses.

One stubborn obstacle is lack of knowledge on insect vectors. The difficulty of determining the insect vector of phony peach was ably demonstrated by Turner (79) and associates after concerted studies over a span of years. Fortunately, since most virus troubles are encountered in orchards, the vectors can be largely circumvented by employing disease-free plants.

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[2] The test solution employed was ferric ammonium sulfate dissolved in water. The dark purplish black color imparted to the yellowish-orange FAS solution demonstrated a high tannin content which is characteristic and diagnostic of Mazzard roots.

Disease-free trees cannot be achieved unless or until both the roots and scions are certified disease-free. Attempts to obtain support for making visits to rootstock seed sources between 1940 and 1943 were unavailing. The objective of a seed certification program across state lines did not receive active support. The certification of budwood is relatively easy because most of it comes from the local nursery, but rootstocks crossing state lines make the problem regional or national. There is no doubt that certain fruit viruses are seedborne (43, 16, 10, 11). Finally, to be effective the certification program should include careful early season orchard inspection for the two years immediately following planting. The suggestion of Rasmussen and Cation (72) for a zonal eradication program for old orchards is commendable.

Milbrath and Zeller (55) reported a rough bark disease of flowering cherry in Oregon to be a virus disease. It is of interest that the same or a similar trouble (Figure 39) is also present on the East Coast, as about five years before their report the writer had received similar specimens from which he was unable to isolate either bacteria or fungi.

The cross-inoculation test planting at Ithaca gave the most valuable year-to-year record of stone fruit viruses of any undertaking. In it each virus isolate could be cross-indexed or cross-inoculated on nine standard varieties (Montmorency sour cherry, Bing, Black Tartarian, and Napoleon sweet cherries, Elberta and Rochester peach varieties, and Damson, Lombard, and Italian plums) and one to four rootstocks (Mahaleb, Mazzard, Myrobalan, and peach seedlings). Some varieties were added or changed during the years. This test planting was invaluable for host range studies; to mention only one illustration it revealed the susceptibility of the new Stanley prune to Lombard plum latent virosis (Figure 40). It facilitated the strain studies on prune dwarf (36). Presumably healthy myrobalan plum seedlings developed mottle and asteroid spot symptoms (40). So also were the other seedlings revealing symptoms of seed-borne conditions.

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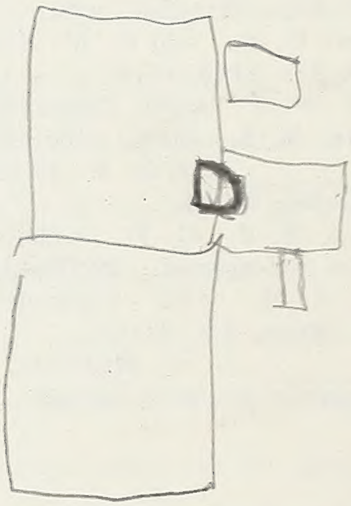
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